AIR FORCE HANDBOOK 10-222, VOLUME 7
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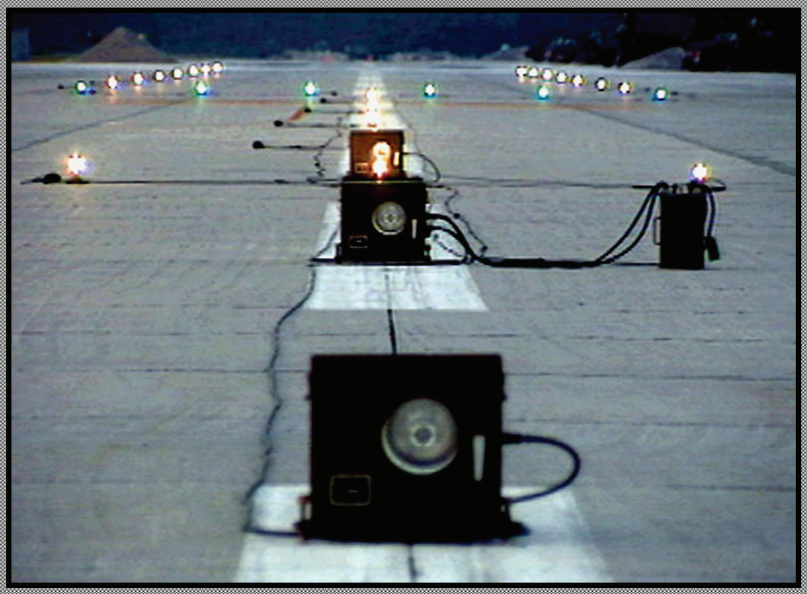
EMERGENCY AIRFIELD LIGHTING SYSTEM (EALS)



DEPARTMENT OF THE AIR FORCE

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BY ORDER OF THE SECRETARY OF THE AIR FORCE

AIR FORCE HANDBOOK 10-222, VOLUME 7
1 May 2006

Operations

EMERGENCY AIRFIELD LIGHTING SYSTEM (EALS)

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This handbook provides a brief system description and summarizes key steps for installing, operating, maintaining, troubleshooting, and repacking the Emergency Airfield Lighting System (EALS). It contains checklists as quick references for civil engineer electrical and power production craftsmen. This handbook augments, but does not replace TO 35F5-3-17-1, *Lighting System, Airfield, Emergency A/E82U-2*. The TO takes precedence over this handbook in all cases. Personnel must have the applicable technical orders on site whenever installing, operating, or maintaining the equipment.

Throughout this handbook, you will see ***NOTES*** and ***HINTS***. They provide supplemental information to help you understand why actions are required or how to perform a task. You will also see **WARNINGS** and **CAUTIONS**. They provide information to avoid safety problems.

NOTE: Ensure all records created as a result of processes prescribed in this publication are maintained in accordance with Air Force Manual (AFMAN) 37-123, *Management of Records*, and disposed of in accordance with the Air Force Records Disposition Schedule (RDS) located at **https://webrims.amc.af.mil/**.

SUMMARY OF CHANGES

This revision contains substantial revisions requiring complete review. Of specific significance: additional **WARNINGS** and **CAUTION** statements have been added to stress safety; added Attachment 4, *Light Fixture Staking Procedures;* and Attachment 5, *Adjusting PAPI Tilt Switch;* added graphics depicting the installation teams' routes to clarify installation instructions (Figures A7.11 thru A7.14).

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Chapter 1

SYSTEM DESCRIPTION

1.1. Purpose and Capability. The EALS is a rapidly installed runway lighting system designed for contingency airfields and other locations that need temporary airfield lighting. The contingency system supports flying operations at night and during periods of reduced visibility. It provides runway edge lighting, approach lighting, threshold/end lighting, taxiway lighting, Precision Approach Path Indicator (PAPI) lights, Distance-To-Go (DTG) marker lighting, and obstruction lighting. As a minimum, runway edge and approach lights are required. Distance-to-go and aircraft arresting system marker lights are required for runways that conduct jet aircraft operations, and recommended for runways that conduct only propeller-type aircraft operations. Position and install all lighting components described in this handbook unless otherwise directed by the MAJCOM operations and flight safety officer.

Install and secure the EALS on all types of surfaces (e.g., sand, frozen earth, mud, ice, asphalt, and concrete). The system can light a runway, or minimum operating strip (MOS), up to 150 ft wide by 10,000 ft long. Install the system with a six-person crew, split into four teams, and two general-purpose vehicles. At least two task-certified Electrical Systems personnel, one on Team A and one on Team B, will be required to safely install the EALS. Personnel can install the system wearing chemical defense ensembles or arctic clothing.

1.2. Subsystems. The EALS has three subsystems: the lighting subsystem, the power and control subsystem, and the packaging subsystem. **Table 1.1** highlights the major elements in each subsystem.

1.3. Theory of Operation.

1.3.1. The power source for the system consists of two MEP-805A, 30 kW, 50-60 Hz, tactical-quiet diesel engine-driven generator sets. One generator serves as the primary unit—the other as a standby unit—to provide input power to a 20-kW constant current regulator via the control

panel. ***NOTE:*** The generators have one "non-standard" feature, a remote start kit that allows generator operation from the system control panel.

Table 1.1. EALS Subsystems.

LIGHTING SUBSYSTEM	*POWER & CONTROL SUBSYSTEM*	*PACKAGING SUBSYSTEM*
Edge Lighting	Generators	Trailers
Approach Lighting	Regulators	Cable Reels
Threshold/End Lighting	Controls	Containers
PAPI Systems	Cabling	Tools
Taxiway Lighting	Cable Protection	Spares
DTG Marker Lighting		
Obstruction Marking		

1.3.2. The 20-kW constant current regulator requires 416 VAC input. It provides a constant current power source for the runway lighting circuit. It powers all the lighting equipment except the obstruction lights. It has three output current levels and accurately regulates output current to within +/- 3%. The primary control panel is the primary location to control the power delivered to and from the regulator. In addition, the regulator panel has alternate control capability. Except for the approach strobes, a single switch controls all the lights on the series circuit.

1.3.3. The function of the control panel is to allow the operator to control the operation of the generators and other EALS components and to allow a system blackout (de-energizing runway and strobe lights). The primary control panel automatically transfers the load to the standby generator if the primary unit fails. The primary control panel can also manually transfer load from one generator to the other. In addition, the primary or remote control panel will start and shutdown the generators.

1.3.4. The control panel has a rotary switch with three settings to control the intensity of the runway lights. The nominal regulator output at each setting is 4.8 amps (low), 5.5 amps (medium), and 6.6 amps (high). The switch controls the intensity of the edge lights, approach lights, thresh-

old/end lights, taxiway lights, and DTG (and aircraft arresting system) marker lights. ***NOTE:*** A rotary switch on the regulator panel will also control light intensity.

1.3.5. The series lighting circuit powers the approach strobes located at each end of the runway. An approach strobe segment consists of one strobe master unit and two strobe slave units. The strobe units flash in sequence from the outermost to the innermost unit at one end of the runway or the other. A three position rotary switch on the control panel selects the appropriate approach strobe segment. With the series circuit energized, the capability exists to turn the approach strobes on or off independently of the runway lights.

WARNING: Looking directly into an operating strobe flasher unit may cause eye damage.

1.3.6. There are spares for every component in the EALS. This includes the regulator and the control panel. The backup regulator and backup control panel do not have the full capabilities of the primary units. Only the primary control panel/regulator is capable of operating a two-generator system to automatically transfer load from the primary generator to the back-up generator. This is because **the backup control panel only has one generator connection**.

1.4. Packaging. The air transportable EALS six trailers fit within the space of three C-130 aircraft pallet positions (Figure 1.1). The placement of the items on cable reels and in storage cabinets provides for easy access to the system components during installation. ***NOTE*:** There are enough components on four of the trailers (#2, #3, #4, and #5) to install a lighting system on a 50-ft by 5,000-ft MOS, which fit on two pallet positions. **Table 1.2** identifies the use of each trailer.

Table 1.2. Use of EALS Trailers.

TRAILER	PRIMARY USE
# 1	Contains primary control panel and regulator with connections for two generators. Also, contains taxiway lights and reflectors, obstruction lights, and a spare PAPI and strobe master unit.
# 2	Contains fixtures and cables for lighting one end and one edge of a runway.
# 3	Contains fixtures and cables for lighting opposite end and edge of runway.
# 4	Contains backup control panel and regulator with connection for one generator. Also contains strobe slave units and extra cables for edge and end lighting plus generator power and control cables and ground cables.
# 5	MEP-805A generator; serves as primary or backup power source.
# 6	MEP-805A generator; serves as primary or backup power source.
Attachment 2 lists the contents of each trailer.	

Figure 1.1. EALS Trailers.

PAPI CONTAINER & OBSTRUCTION LIGHT CONTAINER
STROBE MASTER UNIT CONTAINER

TRAILER #1

STROBE MASTER UNIT CONTAINER
TWO PAPI CONTAINERS

TRAILER #2

STROBE MASTER UNIT CONTAINER
TWO PAPI CONTAINERS

TRAILER #3

FOUR STROBE SLAVE UNIT CONTAINERS

TRAILER #4

MEP-805A GENERATOR

TRAILER #5

MEP-805A GENERATOR

TRAILER #6

1.5. Limitations. The EALS is a ***temporary*** contingency lighting system not intended for ***permanent*** use.

1.5.1. Although originally designed for a minimum operating strip and short duration contingencies, the systems are now lighting full-length runways. In addition, military operations are increasingly becoming more semi-permanent requiring long-term EALS installations. In these scenarios, anchor the system securely, including cables, throughout the installation.

1.5.2. While rated at 20 kW, the EALS regulator cores are factory-adjusted for a maximum output of 13 kW. This limits the output voltage of the regulator allowing the use of smaller diameter cables. This, in turn, reduces the overall volume of a packaged EALS and minimizes the number of aircraft pallet positions needed to move the complete system. However, there is a penalty for the reduced regulator output. The regulator cannot power the system to full intensity when the series circuit is fully loaded (or nearly so). This limitation occurs when all, or most, of the lights are in the complete, or near complete, 150-ft by 10,000-ft series circuit. In that situation, even though the intensity selector switch is set on high, the maximum output current will be limited to less than the nominal 6.6 amps, and the system lights will not illuminate to full intensity. Do not adjust the regulator's power transformer taps beyond tap setting X1-X3 in an attempt to compensate for the reduced regulator output. Doing so will cause the regulator output voltage to exceed the cable voltage rating, potentially causing system failure.

1.5.3. The EALS design limitations prevent it from supporting instrument flight rules (IFR) operations. Its design limitations also reduce system effectiveness when meteorological visibility is less than four statute miles. However, the EALS does not prevent the use of IFR operations where the appropriate navigational and additional visual aids are in place for this purpose.

1.6. Essential Technical Orders. T.O. 35F5-3-17-1, *Lighting System, Airfield, Emergency A/E82U-2*; TO 35C2-3-446-11, *Generator Set, Skid Mounted, Tactical Quiet* (MEP-805A).

Chapter 2

SYSTEM LAYOUT

2.1. Placement Rules. The rules for placing the EALS lighting elements generally conform to standard Federal Aviation Administration (FAA) and Unified Facilities Criteria UFC 3-535-01, *Airfield Lighting Systems*. Written for emergency conditions, the EALS technical order does contain allowable deviations from the above criteria. Notes in this handbook describe allowable deviations for emergency conditions following the standard placement rules. ***NOTE:*** When time and conditions permit, use the standard placement rules.

2.2. Edge Lights. The system contains 116 fixtures (includes four spares) and 113 isolation transformers (IL) (includes 1 spare), enough for a 10,000-ft long runway plus seven approach lights at each end. The fixture uses a clear glass lens, 45W lamp, and a 45W IL. ***NOTE:*** Lights use the same 45W isolation transformers as the taxiway lights and distance-to-go marker lights (see Figures 2.1 and 2.2).

Figure 2.1. Edge Light

Figure 2.2. Edge Light Next to Edge Marker

2.2.1. Position fixtures on each side of the runway in parallel with each other. Place fixtures inside edge markers and up to 10 ft from the edge of runway. Position the isolation transformer outboard of fixture (see Figure A7.3).

2.2.2. Do not place fixtures in intersections with taxiways or in the tape sweep area of aircraft arresting systems (see Attachment 2).

2.2.3. Secure fixture with stakes or temporarily stabilize with ballast rings.

2.2.4. Spacing fixtures up to 300 ft apart is an allowable deviation in emergency conditions; spacing greater than 200 ft requires two runway cable segments between fixtures.

2.3. Threshold/End Lights. System contains 33 fixtures and 33 isolation transformers (IL) (includes one spare each), enough for a 150-ft wide runway. ***NOTE*:** Fixture bases are interchangeable with edge, approach, and taxiway lights. Only lens color and lamp wattage varies. Fixture has split red/green glass lens, 120W lamp, and a 100W IL (see Figures 2.3 thru 2.5).

Figure 2.3. Threshold/ end light fixture

Figure 2.4. Runway threshold lights

Figure 2.5. Runway end lights

2.3.1. Placed in two groups of five, symmetrically and on a line perpendicular to the centerline on each end of the runway (see Figure A7.4).

2.3.2. Locate the fixtures within 10 ft of the usable surface at the end of the runway. Uniformly space the fixtures 10 to 15 ft apart. The out-board-most light in each group must be in line with the runway edge lights.

2.3.3. The lights shall be red toward the runway and green toward the approach. Place the isolation transformer outboard of fixture.

2.3.4. Firmly anchor fixtures by staking. Temporarily use two ballast rings if necessary, return later to stake fixtures.

2.3.5. Deviations in emergency conditions allow fixtures to be offset no more than 5 ft from the end of the runway; space at 10 ft intervals toward the centerline.

2.4. Approach Lights. Approach lights use the same fixture and isolation transformer as edge lights. The fixture has a clear glass lens, 45W lamp, and a 45W IL.

Figure 2.6. Approach light fixture

2.4.1. Place the fixtures every 200 ft beyond the threshold and in line with the centerline (see Figure A7.5).

2.4.2. At the 1000-ft crossbar, place the center light 3 to 10 ft on approach side of the strobe slave unit nearest the threshold. Place a light 10-ft left and right, inline with the center light.

2.5. Approach Strobes. System contains three master strobe units (includes 1 spare), four slave units, and five series circuit adapters (SCAs) (includes 1 spare); enough to provide a strobe segment at each runway end.

Figure 2.7. 1000' crossbar

2.5.1. Place the master strobe unit in line with the centerline and SCA at the 1200-ft point beyond the threshold (also see Figure A7.6).

2.5.2. Place a slave unit at the 1000-ft and 1400-ft points on the extended runway centerline. Point all strobes towards the approach.

Figure 2.8. Strobe Master and SCA

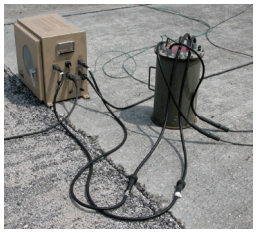
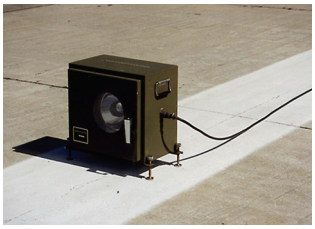


Figure 2.9. Strobe Outboard Slave Unit



2.6. PAPI Lights. The system contains two PAPI units plus a series circuit adapter (SCA) for each end of the runway, plus a spare PAPI unit. The location and alignment may vary to meet local conditions. Determine the location and aiming of the PAPI by performing required corrections for elevation differences between the PAPI units, threshold, and runway reference point (RRP) if necessary.

Figure 2.10. Outboard unit

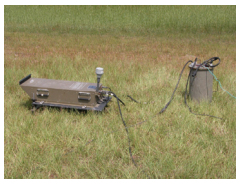


Figure 2.11. Inboard unit

Figure 2.12. Complete PAPI set-up

2.6.1. Place the units on left side of the runway when viewed from the approach end. Attachment 3 contains instructions for determining the correct distance to place the PAPI from the threshold (see Figure A7.7). Place the units no closer than 50 ft to a runway, taxiway, or apron. Do not place other lights so close to the PAPI as to cause pilot confusion.

2.6.2. Position the centerline of the inboard unit 50 to 60 ft from the edge of the runway. Position the outboard unit 20 to 30 ft from the inboard unit (the larger separation increases the useable range of the system). Place the face of both units on a line that is perpendicular to the centerline of the runway, and aim units out toward approach end.

2.6.3. The beam centers of both units shall be within 1 inch of a horizontal plane. The horizontal plane shall be within 1 ft of the runway elevation at the RRP. Secure the support bases using three stakes.

Figure 2.13.
DTG/AAS Marker Light

Figure 2.14.
DTG Marker

Figure 2.15.
AAS Marker

Figure 2.16.
MAAS with Marker

2.7. Distance-To-Go (DTG) Marker Lights. System contains 10-45W ILs and unidirectional fixtures that accept 45W PAR lamps. Markers are not part of the EALS (see Figures 2.13 and 2.14).

2.7.1. Place lights every 1000 ft to illuminate the diamond shaped DTG markers. Start 1000 ft from the end of the runway and proceed to the 5000-ft marker (see Figure A7.8).

2.7.2. Sign is located on right side of runway as viewed from the approach end and 25 to 50 ft from edge of runway, or no more than half the width of the runway/MOS, whichever is less.

2.7.3. Keep DTG markers and lights away from PAPI units to reduce pilot confusion.

2.8. Aircraft Arresting System Marker Lights. EALS has no fixtures designated for this purpose. Use lights from the 5,000 ft DTG markers in order to illuminate the AAS markers (see Figures 2.15, 2.16 and A7.8).

2.8.1. Position fixture to illuminate the diamond shaped aircraft arresting system sign. Sign is located on right side of runway as viewed from the approach end, 25 to 50 ft from the edge of the runway, and in line with the arresting system cable.

2.8.2. If coincident with a DTG marker, place them five feet outside DTG marker. Keep fixtures away from PAPIs to reduce pilot confusion.

2.8.3. Following an attack, place arresting system markers 35 ft from the edge of the runway to minimize risk from UXO.

Figure 2.17. Taxiway light fixture

Figure 2.18. Taxiway Exit Lights

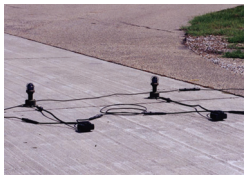


Figure 2.19. Taxiway Reflector

Figure 2.20. Obstruction Light

2.9. Taxiway Lights/Reflectors. System includes 40 light fixtures, 40 ILs, and 250 reflectors to light the taxiways. Fixtures use a blue glass lens, 30W lamp and 45W ILs (see Figures 2.17 thru 2.19).

2.9.1. Position parallel to the taxiway on sections closest to the runway (see Figure A7.9). Place the fixtures no more than 10 ft from edge of the taxiway. Space the fixtures 50 ft apart in straight sections and 25-ft apart in curves.

2.9.2. Place taxiway exit lights (double lights) at beginning of the curve into a taxiway. Place the inboard light 2-ft outside the line of edge lights. (Be sure inboard light is not in line with edge lights.) Place the second light 5-ft outboard the first light and perpendicular to the runway/ MOS centerline.

2.9.3. Place reflectors on sections farthest from the runway not covered by the taxiway lights to free up lights for other taxiways. There is no set distance away from runway for this transition.

2.9.4. In emergency conditions, spacing between lights cannot exceed 220 ft in straight sections or 100 ft in curved sections.

2.10. Obstruction Lights. System has 10 battery-powered blinking red lights. Place on or around obstructions. ***NOTE*:** If more than 10, place at the 10 most significant obstructions. Inform airfield operations of all airfield obstructions.

2.11. Regulators/Generators. System includes a primary and backup regulator, and two MEP-805A generators as power sources.

Figure 2.21.
Regulator

Figure 2.22.
MEP-805A

2.11.1. Place the regulator at any place in the circuit that provides easy access for servicing the generators. Preferably, position the units 200-600 ft from the runway; minimum distance is 60 ft (see Figure A7.10).

2.11.2. Generator placement from the regulator can vary so long as the total length of the power cable and control cable used to connect the generators with the regulator does not exceed 1000 ft.

2.11.3. Place the auxiliary fuel supply within 25-ft of the generators.

Chapter 3

PREINSTALLATION

3.1. Required Information. Before beginning the EALS installation, the team must get information on the runway location, taxiway locations, direction of aircraft takeoffs and landings, approach slope/PAPI aiming angle, arresting system location, and light systems to be set up. **Checklist 8.1** lists the required information needed before the installation begins.

3.2. Pre-Employment Checks. Before the system is used, perform equipment checks outlined in **Checklist 8.2** to ensure the equipment is ready to go.

3.3. Pre-Marking of Light Locations. Procedures in this handbook follow the assumption that a marking crew will mark the location of the runway, taxiways, approach lights, strobes, PAPI, DTG markers, and the aircraft arresting systems prior to the EALS installation. If the locations are not marked, install the lights using the placement criteria in this handbook. Attachment 3 provides instructions to determine the correct distance between the threshold and PAPI location.

Chapter 4

INSTALLATION

4.1. Installation Team. Six people organized into four teams, with two general-purpose vehicles, can easily set-up the EALS. At least two task-certified Electrical Systems personnel, one on Team A and one on Team B, will be required to safely install the EALS. Both TEAM A and TEAM B have two members and one general-purpose vehicle each. TAG A and TAG B are each a one-person team that will travel on foot for the majority of the installation. During installation, the two-person teams lay the series circuit cable and place the equipment on the ground, while the TAGs follows on foot connecting the components to the primary series circuit (see Figures A7.11-A7.14).

4.1.1. The two-person teams start at opposite ends of the runway and perform identical tasks, with two exceptions. TEAM A installs all PAPI lighting, while TEAM B sets up the regulator and generators. The "A" and "B" designation is arbitrary and used only to differentiate between the two teams, the TAGs, the ends of the runway, and the sides of the runway. (***NOTE*:** In this handbook, TEAM A installs the approach lighting for a unidirectional runway.)

4.1.2. When the runway installation is complete, divide the six persons and two general-purpose vehicles into two teams for taxiway installations. TEAM A consists of four persons and one general-purpose vehicle. TEAM B consists of two persons and a general-purpose vehicle.

4.1.3. TEAM-A installs taxiway lighting while TEAM B places obstruction lights and then returns to the taxiway to assist TEAM A if necessary.

4.2. Safety Summary. Observe safety rules at all times. Work on or near energized electrical equipment is prohibited by AFI 32-1064, Electrical Safe Practices, except in rare circumstances and then only when approved by the BCE or equivalent. Authorization is not required for tasks such as voltage measurement on circuits operating less than 600 V, as long as maintenance or

repair is not performed and safe practices and appropriate PPE are used. **Checklist 8.3** highlights safety practices the installation team must follow.

4.2.1. Do not replace components or make adjustments inside the equipment with the high voltage supply energized. Under certain de-energized conditions, dangerous potentials may still exist in the system due to charges retained by capacitors. To avoid casualties, **always remove power, discharge, and ground circuits before touching them**. Adhere to all lockout/tag out requirements and account for all team members before re-energizing the system. Under no circumstances should any person reach into or enter enclosures for the purpose of servicing or adjusting the equipment except in the presence of someone who is capable of rendering aid and only when wearing proper PPE. Only personnel trained in modern methods of resuscitation will work with or near high voltages.

4.2.2. Determine the personal protective equipment (PPE) requirements for the intended work location, to include arc flash protection. Perform a flash hazard analysis of the system in accordance with NFPA 70E. As a minimum, use the following:

4.2.2.1. Flash protection boundary: use 20" as a minimum. The flash protection boundary is an approach limit at a distance from exposed live parts or enclosed live parts if operation, manipulation, or testing of equipment creates a potential flash hazard, within which a person could receive a second degree burn if an electrical arc flash were to occur. A worker entering the flash protection boundary must be qualified and must be wearing appropriate PPE.

4.2.2.2. Minimum level/rating of PPE required: 8 cal/cm^2. This is the minimum level of personal protective equipment in calories per centimeter squared, as evaluated by procedures outlined in NFPA 70E, with the intent to protect the worker from the thermal effects of the arc flash at 20 inches from the source of the arc.

4.2.2.3. Hazard risk category 2 requirements (8 cal/cm^2 rating minimum for clothing/equipment): flame resistant (FR) shirt and FR pants, OR FR coveralls over cotton BDUs, OR FR coveralls over

other non-melting, flammable materials (i.e. untreated cotton, wool, rayon, or silk, or blends of these materials) with a fabric weight at least 4.5 oz/yd, PLUS cotton underwear, FR gloves, FR face shield, and electrical hazard (EH rated) boots or shoes shall also be worn.

4.2.2.4. DELETED.

4.2.3. Components packed in removable containers are heavy; do not attempt to lift or carry a loaded removable container or its contents alone or personal injury may result. The end of cables can fly off the reel causing injury to personnel. Series circuit adapters are heavy; use two people to carry them or personal injury may result.

4.2.4. Notify Airfield Operations of any airfield lighting system irregularities and/or of any obstructions on or near the runway.

4.3. Equipment Distribution for the Runway Installation. Trailers #2 and #3 each contain most of the lighting equipment and tools needed to install the EALS on one end and one side of a runway. When directed to install the EALS, TEAM-A hooks up to trailer #2 and TEAM-B tows trailer #3. Before moving, reposition the strobe master units and the PAPIs from the top of trailers 2 and 3 to the beds of the tow vehicles. If desired, leave these items on the trailer and download as needed to save space in the bed of the vehicle. Each team should draw additional items needed from the other trailers, as outlined in **Checklist 8.4** and **Checklist 8.5**, and load those items in the back of the team's vehicle.

4.4. Runway Lighting Installation Procedures. Checklist 8.6 summarizes the steps for installing the EALS to include the edge, threshold, approach, strobes, and distance-to-go (DTG) marker lights.

4.4.1. As a minimum, runway edge and approach lights are required. Distance-to-go and aircraft arresting system marker lights are required for runways that conduct jet aircraft operations, and recommended for runways that conduct only propeller-type aircraft operations. Position and install all lighting components described in this handbook unless otherwise directed by the MAJCOM operations and flight safety officer.

4.4.2. Install the PAPI correctly to ensure pilot and aircraft safety. **Checklist 8.7** summarizes the installation instructions. Setting the PAPI system at approach angles other than 3° may cause accidents, injury, or loss of life during landings. In the event of obstacles in the approach at the 3° setting, contact the appropriate authority for approval to change the visual glide path angle.

4.4.3. Unless specifically noted, the procedures in **Checklist 8.6** apply to both TEAM A and TEAM B. The checklist also specifies the actions performed by each TAG. ***NOTE*:** The TAG can stay with the team to help unwind the cable from the reel and place the light fixtures. In that case, the team connects and positions the transformers and light fixtures to the series circuit while laying the cable.

***NOTE*:** In these procedures, the term "**place**" refers to positioning components at or near the installation location, but not actually connecting them. "**Install**" means to both place and connect the components.

4.4.4. Lessons learned during Operation IRAQI FREEDOM revealed that all fixtures should be inboard of isolation transformers. Jet blasts caused inboard transformers to collide into fixtures resulting in damage and separation of the runway cable. Where possible, secure light fixtures with stakes during initial installation to prevent jet blasts from relocating and damaging fixtures. Once system installation is complete and time permits, light fixtures, DTG marker lights, and taxiway reflectors located behind aircraft turn points or at other areas where excessive wind is possible will require stakes to securely anchor them. Ballast rings alone proved inadequate in these areas. Use steps in **ATTACHMENT 4** to anchor the light fixtures. **Table 4.1** lists the additional installation tools and equipment required to perform the steps in **ATTACHMENT 4**. This equipment is not included in the EALS kit but can be barrowed from the Electrical Systems tool kit at the installation location.

Table 4.1. Additional Tools/Equipment for Anchoring Fixtures.

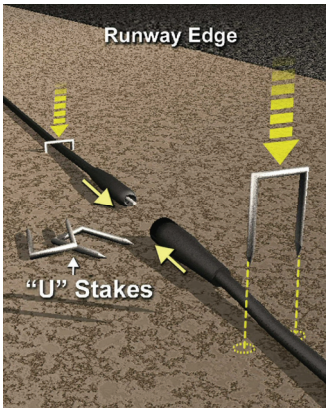
ITEM	QTY
Hammer Drill	1
½" Diamond Drill Bit	4
Extension Cord, 120V, 25' Minimum Length	1

4.5. Cable Payout. Cable payout requires at least two persons and one vehicle. One person will drive the vehicle while the second person operates the cable reel. Be sure to control the payout of the cable from the reel. Dispensing the cable too quickly can create a backlash (rats nest).

4.5.1. In addition, as the cable reels turn, some cables may loosen on the reel. Should a cable terminal start hitting anything as the reel rotates, immediately stop the vehicle, and secure the loose or loosened cable end. Any of these conditions can damage the cable and/or the reel.

4.5.2. Different diameter cables will unwind from the reel at different speeds. Laying two cables with different diameters at the same time will create a backlash (rats nest) with the smaller diameter cable, or will drag the larger diameter cable along the ground.

Figure 4.1. Cable Anchored with "U" Stakes.



***NOTE*:** To prevent installed cables from disconnecting in areas where high jet blasts occur, stakes, in the shape of a "U," can be purchased/manufactured to securely anchor the cables (see Figure 4.1). Burying the cable may produce excessive ground faults during wet periods and make it difficult to find opens.

4.5.3. The 125-ft and the 1000-ft ground wires provide maximum placement flexibility during installation, but are likely to be longer than needed. They may be cut to size, but replace them with full-length wires when repackaging the system.

4.6. Installation Procedures for Taxi-way and Obstruction Lighting. Checklist 8.8 details the steps for installing the taxiway lights and obstruction lights. Repeat this process for each taxiway that intersects with the runway. These procedures assume the location of the taxiways or taxi paths are marked before installation of the lights.

> **WARNING:** Always disconnect power prior to installing taxiway lighting or serious injury or death due to electrical shock may result.

A four-person team (TEAM A) installs the taxiway lighting by first placing the fixtures, isolation transformers, and cable. Then the team will connect the components into the primary series circuit. After placing the lights, transformers, and cables into position, one or two people can follow the other team members to position the lights and make the connections.

Independently, a two-person team (TEAM B) places the obstruction lights. Notify Airfield Operations of any obstructions on or near the runway.

4.7. Regulator/Generator Installation. **Checklist 8.9** summarizes the steps for installing the EALS regulator/control panel and the generators.

4.7.1. The cables that connect the generators to the regulator will limit generator placement. The EALS contains sufficient generator power cables and control cables to place one generator up to 1000 ft away from the regulator.

4.7.2. Mark and protect generator control cables to prevent vehicles from driving over them. Generator control cable damage or disconnection will cause the generator to shut down. Replace or repair defective control cables as soon as time permits.

4.7.3. When installing two generators, one is usually set up within 20 ft of the regulator, while placing the second up to 1000 ft away. These distances are not mandatory. Place the two generators at any distance from the regulator so long as the total length of the generator power and con-

trol cables does not exceed 1000 ft. ***NOTE*:** When placing both generators more than 20-ft from the regulator, you will need a longer ground cable for one of the generators. You have three options: swap a 125-ft ground wire for a 25-ft wire; obtain wire from base supply, or cut the 1000-ft ground cable into smaller lengths.

WARNING: Never attempt to start the generator set if it has not been properly grounded or serious injury or death by electrocution could result.

4.7.4. The procedures in the technical order call for connecting generators and regulator to a common ground. This creates an electrical bond between the generator, regulator, and control panel. Rather than running this wire long distance, you can establish a separate ground at the generator. Under some circumstances, lack of an electrical bond may cause a regulator malfunction.

4.8. Generator Set Up. Follow **Checklist 8.10** to properly configure the generators to operate the EALS from the control panel. If you must use a replacement MEP-805A that does not have a remote start kit, you can remove and install a remote start kit and blackout box from the malfunctioned EALS generators; the TO contains installation instructions.

Chapter 5

OPERATIONS

5.1. System Operations. Checklist 8.12 covers the procedures for activating and operating the system from the primary control panel on trailer #1. **Checklist 8.13** covers procedures for using the backup control panel on trailer #4.

WARNING: Use extreme caution when operating this equipment. Hazardous voltages capable of causing serious injury or death may be present.

CAUTION: Account and locate all team members prior to performing a functional check or operating the system.

5.2. Manual Load Transfer. Checklist 8.14 highlights the steps for manually transferring the load from one generator to the other using the primary control panel on trailer #1.

5.3. System Blackout. The EALS has multiple capabilities to quickly drop power to the lighting circuit if the military situation dictates the need to blackout the lights. **Checklist 8.15** covers those steps.

5.4. Normal and Emergency Shutdown Procedures. Checklist 8.16 addresses normal shutdown procedures for the system, and **Checklist 8.17** covers the emergency shutdown options.

5.5. Operations under Adverse Conditions. In extreme heat, keep the ventilation screen under the regulator free of obstructions.

5.5.1. Heat softens the rubber housing on runway cable connections. Grasp the connectors when disconnecting cables. Reposition any pins or plugs that come loose or that slip further into the connector.

5.5.2. See the generator technical order for instructions on operating the generators in extreme cold or heat or in dusty, sandy, rainy, humid, salt water, and high altitude conditions.

Chapter 6

TROUBLESHOOTING AND MAINTENANCE

6.1. Post Installation Actions. After the system is operational, perform the post installation actions in **Checklist 8.18** as time permits.

WARNING: Do not remove components from an energized runway circuit or serious injury or death due to electrical shock may result.

WARNING: Always disconnect power from system prior to performing any maintenance or serious injury or death due to electrical shock may result.

WARNING: Under certain de-energized conditions, dangerous potentials may still exist in the system due to charges retained by capacitors.

6.2. Circuit Troubleshooting. Checklist 8.19 provides instructions on finding and isolating an open-circuit condition in the primary series circuit. **Checklist 8.20** summarizes the steps for finding a short-to-ground condition in the series circuit.

6.3. Equipment Troubleshooting. Checklist 8.21 provides a checklist for on-equipment troubleshooting. **Checklist 8.22** summarizes troubleshooting steps for the strobe slave units and **Checklist 8.23** for the strobe master units. **Checklist 8.24** lists troubleshooting steps for PAPI units. **Checklist 8.25** covers control panel troubleshooting procedures, and **Checklist 8.26** summarizes troubleshooting steps for the regulator.

6.4. Maintenance. Maintenance actions are not included in this handbook because they are not usually time-sensitive. For detailed instructions, use the system technical order.

Chapter 7

REPACKING

7.1. System Pickup. Recover system by reversing system layout procedures.

> **WARNING:** Always disconnect power from the system prior to repacking or serious injury or death due to electrical shock may result.

If time permits, it is a more efficient use of time to clean the system, perform deferred maintenance, and prepare the system for long term storage during the repack process. Perform system pickup more easily with all members on each team working together. Do not forget to remove the ground rods at the regulator, generators, strobe masters, and PAPI units.

7.2. Cable Repacking Cautions. Be sure to wind the cables tightly on the reels and secure the cable ends. Remember that the male ends of runway cable segments and generator control cable go onto the reel first. The female ends of the PAPI cable, strobe cable, and generator power cable go on first. Stenciled rewind instructions are on the end of the trailers for all cables (Figure A7.15).

7.3. System Storage. Be sure to repair or replace damaged components before placing the system in long term storage. Also, be sure that all components and storage cabinets are dry.

Chapter 8

CHECKLISTS

CHECKLIST 8.1. REQUIRED INFORMATION FOR SYSTEM INSTALLATION			
__	Determine location of runway. Length: _____ ft Width: _____ft		
__	Determine the 1-18 and 19-36 ends of the runway.		
__	Determine which lighting sub-systems to install. __ Edge lights		
	__ Approach strobes	01-18 end: _____	19-36 end: _____
	__ Approach lights	01-18 end: _____	19-36 end: _____
	__ Threshold lights	01-18 end: _____	19-36 end: _____
	__ PAPI lights	01-18 end: _____	19-36 end: _____
	Approach slope angle/ PAPI aiming angle:	01-18 end: _____°	19-36 end: _____°
	Distance from threshold:	01-18 end: _____ ft	19-36 end: _____ ft
	__ Taxiway lights at taxiways: _____ / _____ / _____		
	__ DTG marker lights __ Aircraft arresting system marker lights __ Obstruction lights		
__	If light locations are to be pre-marked, coordinate with marking team. Determine how they plan to mark the location of the runway/ MOS threshold, edges, centerline, approach zone centerline, aircraft arresting systems, taxiways, DTG markers, PAPI lights, and obstruction lights.		
__	Coordinate EALS setup with MAAS installation team. Determine if aircraft arresting system is ___ unidirectional / ___ bidirectional. Determine tape sweep area (light free zone): _____ft (see Attachment 2).		
__	Determine approximate set up location for EALS regulator and generators. The marking team may perform this action.		
__	Determine grounding schemes for power/control equipment and strobe segments.		
__	Coordinate EALS installation and timing with crater repair operations. Do not install EALS components in locations that conflict with repair operations, including debris removal.		

CHECKLIST 8.2. PRE-EMPLOYMENT EQUIPMENT CHECKS

CAUTION: Observe safety precautions in **Checklist 8.3** before inspecting and/or servicing equipment.

__	Inspect and service generators IAW TO 35C2-3-446-11				
		Trailer #5	Trailer #6		
	Visual inspection for leaks, loose cables, and damage	_____	_____		
	Fuel level	_____	_____		
	Oil level	_____	_____		
	Engine coolant level	_____	_____		
	Battery level and charge	_____	_____		
	Belts	_____	_____		
	Tire pressure (65 PSI)	_____	_____		
	Hand brake	_____	_____		
__	Check trailers #1 - #4	# 1	# 2	# 3	# 4
	Tire pressure (65 PSI)	_____	_____	_____	_____
	Hand brake	_____	_____	_____	_____
	Inspect for damage	_____	_____	_____	_____
	Mounted equipment secured	_____	_____	_____	_____
	Inventory trailers	_____	_____	_____	_____
__	Check cable reels	Trailer #2	Trailer #3	Trailer #4	
	Rewind OK	_____	_____	_____	
	Brake OK	_____	_____	_____	
	Freewheels OK	_____	_____	_____	
	Cable secured on reel OK	_____	_____	_____	

CHECKLIST 8.3. SAFETY SUMMARY	
_	Remove all rings, watches, and metal-framed glasses.
_	Always wear steel-toe boots and wear gloves and earplugs as necessary.
_	Use only general-purpose vehicles to tow trailers and always use spotters when connecting trailers. Pintle-hook height should not exceed 18” from ground (additional height can cause tow bar to bend or snap when making turns). Raise tailgate on tow vehicle before moving.
_	Trailers are top heavy--do not exceed 25 mph on paved surfaces or 5 mph on curves and unpaved surfaces. Stay on paved surfaces when possible. When towing more than one trailer, reduce speed and allow extra stopping distance when braking. Do not tow more than three trailers at a time.
_	Engage trailer parking-brake before performing any operation on or around the trailer. Always disengage brake before moving a trailer.
_	Ensure people are clear of lighting components and cables before energizing a circuit and during operation of the EALS.
_	Do not work on an energized circuit. Shut off generators before working on a circuit and disconnect runway cables from regulator output terminals.
_	Do not attempt to lift or carry a loaded removable container or SCA alone. Do not attempt to open or close the UTS drawer alone.
_	Discharge both capacitors before working inside a strobe unit.
_	Do not dispense cable from reel too quickly. Cable ends can fly off reel. Reel operator should wear gloves.
_	Install PAPI approach lights in correct locations & properly set approach angles.
_	Ground generators, regulators, strobe masters, & SCAs **before** energizing the system.
_	Wear proper PPE for potential arc flash hazards (AFI 32-1064, para. 5)
_	Do not look directly into an operating strobe.
_	Do not use 45W isolation transformers with threshold/end lights.
_	Connect generator power & control cables to proper terminals on control panel.
_	Pick up any loose cable protector pins to eliminate FOD potential.

CHECKLIST 8.4. TEAM A: REQUIRED ADDITIONAL ITEMS		
	ITEM	**STORAGE LOCATION**
__	5 – 45W ILs if MOS is longer than 9000 ft	Trailer 1 - RAC
__	2 strobe slave units	Trailer 4 - on top
__	10-ft runway cables segments as needed	Trailer 4 - cable reel
__	4 ground rod segments plus 1 rod driver	Trailer 4 - spare tire box
__	1 ground wire (25-ft)	Trailer 4 - cable reel
__	1 tool kit	Trailer 4 - UTS
__	1 SCA	Trailer 5 – UTS
***NOTE*:** Items below are required when installing PAPIs at both ends of the R/W.		
__	2 PAPI units	Trailer 3 - on top
__	1 PAPI SCA cable	Trailer 3- cable reel
__	2 ground rod segments	Trailer 4 - spare tire box
__	1 ground wire (25-ft)	Trailer 4 - cable reel
__	1 SCA	Trailer 5 - UTS

CHECKLIST 8.5. TEAM B: REQUIRED ADDITIONAL ITEMS		
	ITEM	**STORAGE LOCATION**
__	1 Runway cable adapter, male/male	Trailer 1 – RAC*
__	5 – 45W ILs if MOS is longer than 9000 ft	Trailer 1 – RAC
__	1 Generator unit power cable (pigtail)	Trailer 1 or 2 – RAC
__	1 Regulator power cable (6-ft)	Trailer 1 or 2 – RAC
__	1 Regulator control cable (6-ft)	Trailer 1 or 2 – RAC
__	10’ runway circuit cables as needed	Trailer 4 - cable reel**
__	1 Generator power cable (25-ft)	Trailer 4 - cable reel**
__	1 Generator power cable (250-ft)	Trailer 4 - cable reel**
__	3 Ground wires (25-ft)	Trailer 4 - cable reel**
__	1 Ground wire (1000-ft)	Trailer 4 - cable reel**

CHECKLIST 8.5 continued on next page

CHECKLIST 8.5. TEAM B: REQUIRED ADDITIONAL ITEMS	
__ 3 Ground rod sections plus one driver/rod	Trailer 4 - spare tire box
__ 1 Generator control cable (25-ft)	Trailer 4 - cable reel**
__ 1 Generator control cable (250-ft)	Trailer 4 - cable reel**
__ 1 Tool kit	Trailer 6 – UTS
* Rather than load cable adapter in tow vehicle, it can stay in trailer RAC until needed (if trailer #1 regulator is used, otherwise load it in vehicle). ** When using trailer #4 cables, leave them on the reel until needed.	
***NOTE*:** Items below are for approach lighting and strobes on bidirectional runway.	
__ 2 Strobe slave units	Trailer 4 - on top
__ 2 Ground rod sections	Trailer 4 - spare tire box

CHECKLIST 8.6. RUNWAY LIGHTING INSTALLATION
__ 1. Remove, wrap, and store tarps.
__ 2. Obtain EALS installation details/information (see **Checklist 8.1)**
__ 3. Inspect/service equipment if not done earlier. (see **Checklist 8.2)**
__ 4. Reposition strobe master units and PAPI units from the trailers to the beds of the tow vehicles. (To save room in tow vehicle, strobes/PAPIs may stay on top of the trailers until needed). __ Get additional items as listed in **Checklist 8.4** and **8.5.**
__ 5. Latch RAC door open. Connect trailer #2 to Team A vehicle and secure all cable straps. Disengage brake.
__ 6. Pick up TAG A and drive to threshold. ***NOTE*:** If crater repair operations are still under way, delay component installation in that area to prevent damage. **TEAM B:** Skip to step 13 if not installing approach lights & strobes.
__ 7. Lay runway cable (200' segments) along extended runway centerline from the threshold to the center strobe location (1,200 ft from the threshold). **CAUTION:** Control pay out of cable from the reel. Keep other cables and cable ends secured tightly to the reel.
CHECKLIST 8.6 continued on next page

CHECKLIST 8.6. RUNWAY LIGHTING INSTALLATION

__ 8. At strobe master unit location (Figure A7.6), begin installing strobes.
- __ Unload strobe master, 2 strobe slaves, SCA, and 2 strobe SCA cables.
- __ Unload 2 ground rod segments (3 ft), 2 ground rod couplings, 2 ground lugs, 2 ground cables (125-ft), and the ground rod driver. ***NOTE*:** Can swap a 25-ft ground wire for a 125-ft cable, if desired.
- __ Unload tools (screwdriver, adjustable wrench, and the shorting stick).
- __ Unpack strobe master and slave units, if not already done.
- __ Drive ground rod at least 5-ft into ground and connect the two ground cables to separate lugs on the rod. Connect other ends of the ground cables to the SCA and to master strobe cabinet.

> **WARNING:** High voltages may exist in capacitors C401 and C402. Discharge capacitors before performing any work inside the strobe enclosure or serious injury or death may result.

- __ Connect shorting stick to the ground lug on the strobe master unit.
- __ Short C401 and C402 capacitors in all three units (Figure A7.16).

> **CAUTION:** Do **not** touch flash tubes with bare hands; use packing material between fingers and tubes.

- __ Install flash tubes in all three strobe cabinets by aligning key with slot in socket and firmly pressing the flash tube into the socket. Store packing materials in RAC container.
- __ Set ON-OFF switches (S401) to ON position (Figure A7.17).
- __ Set strobe master S301 switch to REMOTE (Fig A7.18.).
- __ Set strobe segment selector switch (S302) to correspond with the proper runway end: ____ 1-18 or ____ 19-36 (Figure A7.18).
- __ Reload strobe slave units into vehicle.
- __ Unwind and lay a 200-ft strobe cable from strobe master to inboard strobe slave unit. ***NOTE*:** Strobe cable male end stays at strobe master.

CHECKLIST 8.6 continued on next page

CHECKLIST 8.6. RUNWAY LIGHTING INSTALLATION

TEAM proceeds to step 9. TAG A begins separate activities.

__ **TAG:** Position the strobe master unit. Level unit with leveling feet and face window away from the runway.

__ **TAG:** Place the SCA next to the strobe master, and connect the SCA primary leads to the runway cable (Figure A7.19).

__ **TAG:** Connect SCA cables to secondary leads of SCA and to the POWER INPUT connections on the strobe master (Figure A7.20). ***NOTE*:** Secondary leads have different pin sizes. Do not force connection.

__ **TAG:** Connect strobe cables to the strobe master.

> **CAUTION:** Be sure to connect the cables to the correct OUTPUT connectors.

__ 9. Drive to position of outboard strobe slave unit while laying a 200-ft strobe cable along the extended runway centerline.

__ Unload & position strobe slave. Level & face window away from runway.

__ Install flash tube, if not done in step 8.

__ Connect strobe cable to the connector marked SLAVE INPUT. ***NOTE*:** This also applies if using the spare strobe master as a slave.

__ 10. Return to strobe master location. Pick up tools used by the TAG and any extra materials and debris. Ensure there is slack in runway cable leading to the SCA. Leave a 10-ft runway cable segment if necessary.

__ 11. Drive towards position of inboard strobe slave unit paying out 200' runway cable along extended runway centerline.

__ Unload, position, and connect second strobe slave unit, as before.

__ Install flash tube, if not done in step 8.

__ Drop off 3 approach lights, 3 isolation transformers (45W), 3 stakes, and 2 (10-ft) runway cables for 1000-ft crossbar location.

__ Attach RAC containers (with edge/approach lights & isolation transformers) to trailer mounting pegs (2-person lift).

__ **TAG:** At the inboard strobe location, position and connect the 3 crossbar approach lights (Figure A7.21). Space the lights 10 ft apart and 3 to 5 ft in front of the strobe cabinet.

CHECKLIST 8.6 continued on next page

CHECKLIST 8.6. RUNWAY LIGHTING INSTALLATION

__ 12. Drive toward threshold and place approach lights with 45W isolation transformers and stakes (if required) every 200 ft along extension of runway centerline while paying out runway cable (see Figure A7.5).

__ **TAG:** Position each approach light along the extended centerline and connect to transformer, connect transformer to primary series circuit.

__ 13. At threshold, place threshold/end lights, 100W isolation transformers (yellow tape on leads), 10-ft runway cables, and 2 ballast rings (or 1 stake) per fixture. Place outboard of threshold markers if they are in position. ***NOTES*:** Divide width of MOS by 10, and add one for number of light fixtures. Do not connect a 10-ft cable between middle two lights in threshold bar. Place cables so male ends of connectors point in clockwise direction around runway.

__ **TAG:** Position lights no more than 10-ft from threshold and approximately 10-ft apart (Figure A7.4). Adjust spacing between light fixtures so outboard lights are in line with edge lights. Face green side of lens towards approach lights (red side towards runway). Place isolation transformers outboard of lights. Connect 10-ft runway cables to isolation transformers and transformers to lights. Keep cable between transformer and light taut. Connect 200-ft runway cables to and from the approach lighting and strobes between middle two lights on the threshold bar. Secure fixture with ballast rings or stakes.

__ 14. Drive along left side of runway paying out runway cable and placing an edge light with a 45W isolation transformer every 200 ft (Figure A7.3). Place inboard of orange edge markers, if they are in position. (Leave a stake or ballast ring at each light where needed.) ***NOTE*:** Do not place lights at taxiway intersections or in aircraft arresting system tape sweep areas (see Attachment 2).

__ **TAG:** Position lights no more than 10 ft from edge of runway/ MOS, and inboard of edge markers. Place isolation transformers outboard of lights. Connect runway cables to isolation transformers and transformers to lights. Keep cable between transformer and light taut. Place two ballast rings on each light or stake fixtures down if possible.

__ 15. **TEAM A:** Stop at EDGE A PAPI location, install PAPI system (Figure A7.7). See **Checklist 8.7** for installation procedures. When complete, continue edge light installation and laying primary series circuit cable. ***NOTE*:** Ideally, engineering craftsmen will mark PAPI location. Attachment 3 contains instructions for determining correct distance from threshold to PAPI location.

CHECKLIST 8.6 continued on next page

CHECKLIST 8.6. RUNWAY LIGHTING INSTALLATION

__ 16. Place DTG marker lights with 45W isolation transformers and 3 (50-ft) runway cables at 1000-ft markers in the first 5,000 ft on the left side of the runway (see Figure A7.8). ***NOTE* for TEAM A:** Place DTG marker lights only if the runway is to be set up for bi-directional operations.

TAG: Position light to illuminate marker. Connect light to transformer and transformer to the runway circuit using 50-ft cables as needed.

__ 17. Place a marker light with 45W isolation transformer along with two or three 50-ft runway cables outboard of any aircraft arresting system (Figure A7.8). ***NOTES*:** If necessary, use light intended for 5000-ft DTG marker. Lay runway cable (200-ft) outboard of arresting system. ***NOTE* for TEAM A:** Place arresting system marker light only if runway is set up for bi-directional operations.

__ **TAG:** Position light to face marker. Connect light to transformer and transformer to the runway circuit. Use (50-ft) cables as needed. Reposition runway cable outboard of arresting system if previously laid at runway edge.

__ 18. Continue placing lights and laying runway cable to opposite threshold.

__ **TAG:** Continue positioning and connecting edge lights, DTG marker lights, and transformers until meeting up with TEAM A.

__ 19. **TEAM A Only:**

__ If the runway is to be set up for bi-directional operations, drive to the EDGE B PAPI location. Install second PAPI system following procedures in **Checklist 8.7.** Return to END B threshold.

__ Travel back along EDGE A connecting/positioning edge light fixtures, DTG marker lights, and isolation transformers until meeting TAG A.

__ Drive to END A threshold and travel along EDGE B connecting and positioning edge light fixtures, DTG marker lights, and isolation transformers until meeting TAG B.

__ Check with TEAM B to see if they need assistance. Park trailer #2 at predetermined location.

__ If TEAM A is to install taxiway lighting, follow the procedures in **Checklist 8.8.**

CHECKLIST 8.6 continued on next page

CHECKLIST 8.6. RUNWAY LIGHTING INSTALLATION	
__	20. **TEAM B Only:** __ Drive to pre-determined location for regulator/control panel. __ Install the generator(s) and regulator/control panel following the procedures in **Checklist 8.9.** ***NOTE*****:** The primary regulator/control panel (trailer #1) is not normally set up until the taxiway lights, which are located in that trailer, are installed. __ Check with TEAM A to see if they need assistance. __ If TEAM B is to place the obstruction lights, follow the procedures in **Checklist 8.8.**
__	21. Reconnect the series circuit if left open for crater repair activities.

CHECKLIST 8.7. PAPI INSTALLATION	
__	1. At PAPI location, unload 2 PAPI containers, 1 SCA, 2 (50-ft) runway cables, 1 PAPI cable, 1 PAPI SCA cable (5.5 ft), photocell, and 6 stakes. ***NOTE*****:** Attachment 3 contains instructions for determining the correct distance from the threshold to the PAPI location.
__	2. Get 2 ground rod segments (3 ft), 2 ground rod couplings, 1 ground clamp, 1 (25-ft) ground cable, and the ground rod driver.
__	3. Get tools (screwdriver, adjustable wrench, and hammer)
__	4. Connect the runway cables to the primary circuit along the runway/MOS edge and carry the loose ends to the inboard PAPI location.
__	5. Remove 2 PAPI units from containers. Connect tilt switch cable to TILT SWITCH connector (Figure A7.22). Return containers to vehicle.
__	6. After shooting elevations and engineering craftsmen select proper locations, place inboard PAPI 50-60 ft from edge of runway. Place outboard PAPI 20-30 ft from inboard unit (see **Attachment 3** for proper alignment procedures).
__	7. Position SCA and connect the loose ends of the runway cables to the primary leads. If cable is available, the preferred SCA location is behind the outboard PAPI unit, and as far away from runway edge as the PAPI SCA cable assembly will allow (Figure A7.23).
CHECKLIST 8.7 continued on next page	

CHECKLIST 8.7. PAPI INSTALLATION

__ 8. Secure inboard PAPI base (see **Attachment 3** for adjusting PAPI unit elevation at installation location). Level terrain and remove cabinet from its base. Align base so it is parallel with runway centerline, then stake down. Reinstall cabinet on base. ***NOTE*:** Large aircraft may require More robust anchoring.

> **CAUTION:** Do not drive stake heads into PAPI base; it may cause damage.

__ 9. Repeat securing steps for the outboard PAPI.

> **CAUTION:** If elevation difference between the two units exceeds 1 inch, raise or lower the outboard unit or relocate both units to a more level location.

__ 10. Install the photocell. The preferred installation location is on the outboard PAPI unit. Aim eye away from threshold and towards darkest area on airfield (Figure A7.22).

__ 11. Drive ground rod at least 5 ft into the ground. Connect 25-ft ground cable to the rod and the other end to the ground lug on the SCA.

__ 12. Connect SCA cable to J1 secondary lead on SCA and to POWER/CONTROL IN connector on back panel of outboard PAPI (Figure A7.24).

__ 13. Connect the 30-ft PAPI cable to POWER/CONTROL OUT connector on the outboard PAPI and to the POWER/CONTROL IN connector on the inboard PAPI (Figure A7.24).

__ 14. Level and align the PAPI (see **Attachment 3** to level and align PAPI).

> **WARNING:** Approach angles other than 3° may cause accidents, injury, or loss of life during landings. If obstacles are in the 3°approach, contact the appropriate authority for approval to change the visual glide path angle.

CHECKLIST 8.7 continued on next page

CHECKLIST 8.7. PAPI INSTALLATION

__ Level PAPI from side to side. Adjust front 2 knobs to center bubble.
__ Get PAPI aiming device (see Figure A7.21) and set it to the specified approach slope/ aiming angle: 01-18 end _____ ° / 19-36 end _____ °

> **WARNING:** Add 15 minutes (0.25°) to specified angle for inboard PAPI. Reduce angle by 15 minutes for outboard PAPI.

__ Place aiming device on PAPI (tilt switch side) and turn rear-adjusting knob to center aiming device bubble. Tighten the three securing knobs. Return aiming device to RAC. ***NOTE*:** Do not place the aiming device on a rivet.
__ Adjust tilt switch as explained in **ATTACHMENT 5**.

__ 15. Pick up tools and any extra materials and debris.

CHECKLIST 8.8. TAXIWAY/OBSTRUCTION LIGHTING INSTALLATION

__ 1. Connect trailer #1 to tow vehicle and trailer #4 behind trailer #1. ***NOTE*:** Disconnect regulator and control panel on trailer #1 if already connected, or transfer lights and transformers to tow vehicle. Get ballast rings or stakes from trailers #2 or 3, & extra cable protection strips from trailer #2.

__ 2. Drive to location on edge of runway where taxiway intersects.

> **WARNING**: Always disconnect power from the system prior to installing the taxiway lights or serious injury or death due to electrical shock may result.

__ 3. Place taxiway lights and isolation transformers in a gentle sweeping arc between the runway and the taxiway as shown in Figure A7.9.
__ Place two lights at the beginning of the arc near the edge of the runway. These are the taxiway exit lights. The first light should be 2 ft outboard of the edge lights. Place the second light 5 ft outboard of the first on a line perpendicular to the edge of the runway.

CHECKLIST 8.8 continued on next page

CHECKLIST 8.8. TAXIWAY/OBSTRUCTION LIGHTING INSTALLATION

__ Space remaining lights 25 ft apart along the arcs and 50 ft apart in the straight sections of the taxiway. Place lights within 10 ft of the edge of the taxiway.
__ At the same time, lay (50-ft) runway cable segments between lights.
__ Anchor fixtures hit by jet blasts with two stakes.
__ Place a (200-ft) runway cable across the taxiway at the taxiway fixture farthest from the runway. ***NOTE*:** You need the (200-ft) cable to avoid a cable connection in the middle of the taxiway. The connectors do not fit in the cable protection strip. ***HINTS*:** Delay laying this cable until the cable protection strip is in place. Spread out or coil the excess cable on one side.
__ Continue placing fixtures, transformers, cables, and ballast rings/stakes on the other side to the taxiway exit light at the far taxiway/runway connection.

__ 4. Disconnect and remove runway cable that crosses taxiway at the edge of the runway. Tie first taxiway light (taxiway exit light) into primary series circuit.
__ Disconnect the cable at the runway edge light (or a runway cable connection) closest to the taxiway exit light. Pull the two cables off opposite sides of the taxiway.
__ Connect closest cable end to the taxiway exit light transformer. Use (50-ft) or (10-ft) cable segments, as needed, to make this connection.
__ Connect the taxiway lights into the primary circuit on the opposite side after placing the last taxiway light and transformer.

__ 5. Walk the taxiway circuit to connect lights, transformers, and cables. Position lights no more than 10 ft from edge of taxiway. Place isolation transformers outboard of lights. Keep cable between transformer and light fixture taut. Stake fixture or place ballast rings as required.

__ 6. Lay cable protection strip to protect the (200-ft) cable that crosses the taxiway. Mate cable protector sections and pin together. If possible, extend across and beyond the width of the taxiway (Figure A7.26).

CAUTION: Be sure to pick up any loose cable protector pins to eliminate the FOD hazard.

__ Insert cable into the slot. ***HINT*:** Hold the cable connector and press the end of the cable just behind the cable connector into the slot. Then using the connector while holding it to the slot, pull the cable through the slot to the opposite side (Figure A7.27).
__ Secure the cable protection strip with sandbags on the ends.

CHECKLIST 8.8 continued on next page

CHECKLIST 8.8. TAXIWAY/OBSTRUCTION LIGHTING INSTALLATION	
__	7. Install taxiway reflectors beyond the last light as needed. Install along edge of the taxiway in line with taxiway lights. Use the same spacing rules as lights.
__	8. Repeat steps 2 through 7 for other taxiways.
__	9. If towing trailer #1 and it is the primary regulator, return to the predetermined regulator location and reconnect it to generator(s), control panel, and ground.
__	10. **TEAM B:** Remove obstruction lights from container on trailer #1. Load into bed of vehicle. Install batteries. Survey MOS and taxiways for the 10 most prominent obstructions, and place lights there. Turn switch to ON. ***NOTE*:** Use rechargeable lead acid batteries if temperatures fall below zero degrees F. Otherwise use the zinc-chloride batteries.

CHECKLIST 8.9. REGULATOR/GENERATOR INSTALLATION	
__	1. Lay (200-ft) runway cable from the predetermined regulator location to the nearest cable connector on the edge of the runway. Open the series circuit at that cable connector. Connect the female end of the just laid cable to the male end of the open series circuit. Connect the male end of a second runway cable to the female end of the open series circuit, and lay a return cable back to the regulator. Park trailer #3. ***NOTE*:** Use cable on trailer #4 if you need additional runway cable to complete the circuit.
__	2. Move regulator/control panel (trailer 1 or 4) to its predetermined location. __ Set all switches on control panel to the OFF position. On the regulator panel, set circuit breaker (CB1) to the off position (down) and turn intensity selector switch (S1) to the OFF position (See Figures A7.28 and A7.29). __ Connect 25-ft ground cable to grounding lug on the regulator trailer (Figure A7.30) and a second 25-ft cable to the lug on control panel (Figure A7.31).
__	3. Establish common ground at regulator. **WARNING**: Never attempt to start the generator set if it has not been properly grounded or serious injury or death by electrocution could result. __ Get 3 (3-ft) ground rod segments, 3 ground rod couplings, 4 ground clamps, and the ground rod driver. __ Drive ground rod 8 ft deep.
CHECKLIST 8.9 continued on next page	

CHECKLIST 8.9. REGULATOR/GENERATOR INSTALLATION

__ 4. Connect ground cables from regulator and control panel to common ground. Connect each ground cable to a separate ground lug on the ground rod.

__ 5. Inspect and service generator per **Checklist 8.2**, if not already done.

__ 6. Move generators (trailers #5 and/or #6) into position and set them up. If generator is to be located greater than 20 ft from the regulator:

__ Tow generator and trailer #4 from the regulator to the generator site while paying out (250-ft) generator power cable segments from trailer #4. ***NOTES*:** The generator can be located up to 1000 ft from the regulator. For short distances, the team may choose to lay the generator power, control, and ground cables by hand.

__ Position generator. Generator should be as level as possible during operation, well ventilated, and within 25 ft of auxiliary fuel supply. The soil should support the weight of the generator. Location should permit easy access for refueling generator or auxiliary fuel supply. Follow instructions in the T.O. for an indoor installation.

__ Connect pigtails on generator unit power cable to terminal board 2 (TB2). Use terminals L1-L2, L1-L3, or L2-L3 (Figure A7.32).

CAUTION:

Do not use terminal L0.

__ Connect the (250-ft) generator power cable to the generator unit power cable (Figure A7.33).

__ Connect the (250-ft) generator control cable to the connector on the blackout switch box (Figure A7.34). Then tow trailer #4 to the regulator while paying out the (250-ft) control cable segments.

__ Connect the (1000-ft) ground cable from the cable reel on trailer #4 to the common ground at the regulator.

__ Tow trailer to the generator while paying out the 1000-ft ground cable. ***NOTE*:** If desired and the situation warrants, may use 125-ft ground wires, cut wires from base stocks, or cut the 1000-ft wire.

__ Connect the (1000-ft) ground cable to the generator grounding terminal on TB2 (Figure A7.32).

__ Set up generator per **Checklist 8.10.**

__ Return to regulator, and park trailer #4.

CHECKLIST 8.9 continued on next page

CHECKLIST 8.9. REGULATOR/GENERATOR INSTALLATION	
	If generator is to be located less than 20 ft from regulator: __ Repeat above steps, but use (25-ft) generator power, control, and ground cables, and lay by hand.
__	7. Connect the generator power and control cables to the connectors at the side of the control panel (Figure A7.35). **CAUTION:** The control panel on trailer #1 has numbered connectors. Always connect the power and control cables from the same generator to the GENERATOR POWER IN and GENERATOR CONTROL connectors with the same numbers. __ Ensure generator control switch (on the control panel) is in the OFF position. __ Connect generator power cable to the connector on the control panel. __ Connect (25-ft) generator control adapter cable to last segment of (250-ft) control cable. ***NOTE*:** This is necessary because connectors on the 250-ft control cable do not fit the connector on control panel. __ Connect control adapter cable to the connector on side of the control panel.
__	8. Connect (6-ft) regulator control and power cables to the REG CONTROL and REG POWER connectors on the control panel and to the REMOTE CONTROL INPUT and the INPUT VOLTAGE connectors on the regulator (Figure A7.36).
__	9. Perform functional check on regulator & control panel (**Checklist 8.11)**
__	10. Connect the two leads of the runway cable (see step 1) to the OUTPUT CURRENT connectors on the regulator (Figure A7.37). ***NOTE*:** Use the male/male runway cable adapter to complete the connection.
__	11. If used, set up auxiliary fuel supply within 25-ft of the generator and connect the fuel line to the generator. If required, place fuel spill containment around fuel supply. Place a fire extinguisher nearby.

CHECKLIST 8.10. GENERATOR SET UP

__ 1. Safety steps:
- __ At regulator (trailer #1 or #4), be sure all switches on the control panel are in the OFF position. On regulator panel, set circuit breaker (CB1) to off position (down) and turn intensity selector switch (S1) to the OFF position.
- __ Be sure to ground the generator.

__ 2. Be sure to connect the P11/J11 electrical connection if using an auxiliary fuel source (See Figure A7.38). This connection provides electrical power to the generator's auxiliary fuel pump.

> **CAUTION:** If P11/J11 is connected and an auxiliary fuel source is **not** used, the auxiliary fuel pump may burn out.

__ 3. Place DEAD CRANK switch in NORMAL position (Figure A7.39).

__ 4. Ensure position of voltage reconnection terminal board (TB1) is for 240/416V (see Figure A7.40).

__ 5. Set up the generator control panel (see Figure A7.41).
- __ Push in DC CONTROL POWER circuit breaker (located on control bracket behind control panel - Figure A7.42).
- __ Set FREQUENCY SELECT switch to 60Hz.
- __ Set AM-VM transfer-switch to match the pigtail connections on the generator output terminal board (TB2).
- __ Place PARALLEL UNIT switch in UNIT position.
- __ Set MASTER switch to PRIME AND RUN.
- __ Push PRESS TO TEST button on malfunction indicator panel. All lights should light up, and all lights should go out when released.
- __ Press BATTLE SHORT button to test. Light should illuminate.
- __ Press AC CIRCUIT INTERRUPTER button to test. Light should illuminate.

__ 6. Start the generator.

> **CAUTION:** Do not crank engine longer than 15 seconds; wait 15 seconds between attempts or damage to starter may result.

CHECKLIST 8.10 continued on next page

CHECKLIST 8.10. GENERATOR SET UP

__ Rotate MASTER switch to start, and hold until engine starts, oil pressure reaches at least 25 PSI, voltage has increased to near rated value, and engine has reached a stable operating speed. Release switch. ***NOTE*:** In cold weather, push ETHER switch to ON until engine speed stabilizes.
__ If using the auxiliary fuel source, rotate MASTER SWITCH to PRIME AND RUN AUX FUEL position.
__ Warm engine without load for 5 minutes (unless immediate load is required).
__ Check COOLANT TEMP (170°-200°F) and OIL PRESSURE (25-60 PSI) indicators for normal readings.
__ Adjust FREQUENCY knob until FREQUENCY METER indicates 60Hz.
__ Turn voltage adjustment potentiometer until the AC voltmeter (VOLTS AC) indicates 416 volts. Allowable range is 405 – 458 volts. **Compensate for voltage drop if generator is positioned away from regulator, as follows**:

GENERATOR DISTANCE FROM REGULATOR	SET VOLTAGE AT
25 ft	416 volts
250 ft	425 volts
500 ft	434 volts
750 ft	441 volts
1,000 ft	450 volts

__ Press GROUND FAULT CIRCUIT INTERRUPTER TEST button. Indicator window should be CLEAR. Press RESET button; ensure indicator is RED.
__ Place AC CIRCUIT INTERTRUPTER switch in CLOSED position.
__ Recheck voltage and frequency and adjust if required.

__ 7. Stop the generator.
__ Place AC CIRCUIT INTERRUPTER switch in OPEN position.
__ Allow generator to operate 5 minutes without load for a cool down period.
__ Place MASTER SWITCH in OFF position.

__ 8. Repeat steps 2-7 for second generator.

CHECKLIST 8.11. REGULATOR/CONTROL PANEL FUNCTIONAL CHECK

__ 1. Ensure switches on the regulator panel are set as follows (see Figure A7.39):
- __ Intensity selector switch (S1) - REMOTE
- __ Master circuit breaker (CB1) - OFF (down position)

__ 2. Set switches on control panel in the following positions (see Figure A7.28):
- __ GENERATOR CONTROL – OFF
- __ GEN1/GEN2 REMOTE START - OFF
- __ GENERATOR SELECTION - AUTO
- __ LIGHTING CONTROL - OFF
- __ STROBE CONTROL - OFF
- __ PANEL ILLUMINATION - can be in either ON or OFF position

__ 3. Connect male-to-male adapter cable to both OUTPUT CURRENT connectors on regulator.

__ 4. Check automatic switching of generators on main control panel.
- __ Turn GENERATOR CONTROL switch ON. Determine primary unit.
- __ Turn REMOTE START switch for primary unit to AUTO. [Primary unit should start and the RUN and ONLINE indicators for that generator should illuminate.] Wait 5 seconds, then:
- __ Turn REMOTE START switch of backup generator to AUTO. [Nothing should happen.]
- __ Turn REMOTE START switch for primary unit to OFF. [Primary unit should shut down. Backup generator should start. RUN and ONLINE indicators for primary generator should turn off and the back-up unit's should illuminate.]

__ 5. Turn the circuit breaker (CB1) on the regulator panel to on (up) position. [The REGULATOR ON indicator light on the regulator panel should light up.]

WARNING: Immediately turn S1 to off if open circuit protective device does not activate within 2 seconds.

__ 6. Check lighting control from control panel.
- __ Turn LIGHTING CONTROL switch to LOW. Pause while regulator performs internal checks. Low intensity indicator should light up, and ammeter on regulator panel should read between 4.6 & 4.9 amps.

CHECKLIST 8.11 continued on next page

CHECKLIST 8.11. REGULATOR/CONTROL PANEL FUNCTIONAL CHECK

__ Turn LIGHTING CONTROL switch to MED intensity. [Ammeter should read between 5.3 and 5.7 amps for medium intensity setting.]
__ Turn LIGHTING CONTROL switch to HIGH intensity. [Ammeter should read between 6.4 and 6.7 amps for high intensity setting.]
__ Push SYSTEM BLACKOUT button. [The ammeter reading should drop to zero.] Reset BLACKOUT RESET switch.
__ Return LIGHTING CONTROL switch to OFF position, pausing at the LOW intensity setting while the regulator cycles.

__ 7. Check lighting control on regulator panel (Figure A7.43).
__ Turn intensity selector switch (S1) from REMOTE to the low intensity (B1) setting. [Ammeter should show between 4.6 and 4.9 amps.]
__ Turn intensity selector switch (S1) to the medium intensity (B2) setting. [Ammeter should read between 5.3 and 5.7 amps.]
__ Turn intensity selector switch (S1) to the high intensity (B3) setting. [Ammeter should read between 6.4 and 6.7 amps.]
__ Return intensity selector switch to OFF position, pausing at B2 (medium) and B1 (low) intensity settings while regulator cycles.

__ 8. Perform regulator open-circuit test.
__ Turn circuit breaker (CB1) on regulator panel to off (down) position.
__ Remove male-to-male adapter cable from OUTPUT CURRENT plugs.
__ Turn circuit breaker (CB1) to on (up) position.
__ Turn intensity selector switch (S1) to low intensity setting B1. [Regulator should de-energize within 2 seconds, then OPEN CIRCUIT & OUTPUT VOLTAGE LIMIT indicator lights on regulator panel should light.]

> **CAUTION**: Immediately turn intensity selector switch (S1) to off if open circuit protective device does not activate within 2 seconds.

__ Turn intensity selector switch (S1) to OFF position. [The open circuit protective device should reset.]
__ Repeat above two steps to ensure protective device resets.
__ Turn intensity selector switch (S1) to OFF position and main circuit breaker (CB1) to off (down) position.
__ Return intensity selector switch (S1) to REMOTE position.

__ 9. Turn REMOTE START and GENERATOR CONTROL switches on control panel to OFF position. [Generator will shut down.]

CHECKLIST 8.12. ACTIVATING THE EALS FROM TRAILER #1

__ 1. Set switches on the regulator panel as follows (see Figure A7.43):
__ Intensity selector switch (S1) - REMOTE
__ Master circuit breaker (CB1) - off (down position)

__ 2. Set switches on control panel as follows (see Figure A7.28):
__ GENERATOR CONTROL - OFF
__ GEN1/GEN2 REMOTE START – OFF
__ GENERATOR SELECTION - AUTO
__ LIGHTING CONTROL - OFF
__ STROBE CONTROL - OFF
__ PANEL ILLUMINATION - can be in either ON or OFF position

__ 3. Turn GENERATOR CONTROL switch to ON. Determine which generator is the primary unit.

__ 4. Turn the REMOTE START switch of primary unit to AUTO. [The RUN and ONLINE indicators should light.] Wait 5 seconds, then:

__ 5. Turn the REMOTE START switch of the backup generator to AUTO.

__ 6. Turn the circuit breaker (CB1) on the regulator panel to ON.

__ 7. Set LIGHTING CONTROL to proper intensity. Intensity indicator should light up. Adjust as necessary based on pilot request. Without other input, use these visibility conditions to determine proper intensity.

VISIBILITY CONDITION	INTENSITY SETTING
Night over 4 miles	Low
Night 3 to 4 miles	Medium
Night under 3 miles	High

__ 8. Set STROBE CONTROL to proper end ___ 1 – 18 or ___ 19 - 36

CHECKLIST 8.13. ACTIVATING THE EALS FROM TRAILER #4	
__	1. Set switches on the regulator panel as follows (see Figure A7.43): __ Intensity selector switch (S1) - REMOTE __ Master circuit breaker (CB1) - off (down position)
__	2. Set switches on control panel as follows (see Figure A7.29): __ GENERATOR CONTROL - OFF __ LIGHTING CONTROL - OFF __ STROBE CONTROL - OFF __ PANEL ILLUMINATION - can be in either ON or OFF position
__	3. Turn GENERATOR CONTROL switch ON. (The ONLINE indicator should light up.) Wait 5 seconds, then:
__	4. Turn the circuit breaker (CB1) on the regulator panel to ON.
__	5. Set LIGHTING CONTROL to proper intensity. Intensity indicator should light up. Adjust as necessary based on pilot request. If no input, set intensity according to visibility conditions as described in **Checklist 8.12**, step 7.
__	6. Set STROBE CONTROL to proper end ___ 1 – 18 or ___ 19 - 36

CHECKLIST 8.14. MANUAL LOAD TRANSFER AT PRIMARY CONTROL PANEL *(FROM GENERATOR 1 TO GENERATOR 2*)*	
__	1. Turn generator 2 on by turning the GEN 2 REMOTE START switch from AUTO to ON. [The GEN 2 RUN-indicator should light.]
__	2. Turn the GENERATOR SELECTOR switch from AUTO to GEN 2. [The GEN 2 ONLINE indicator should light and the GEN 1 ONLINE and GEN 1 RUN indicators should go out.]
__	3. To reestablish automatic transfer capability, turn GENERATOR SELECTION switch, and GEN 2 REMOTE START switch back to AUTO.
* To transfer from GEN 2 to GEN 1, replace GEN 1 for GEN 2 & GEN 2 for GEN 1	

CHECKLIST 8.15. SYSTEM BLACKOUT AT CONTROL PANEL.	
__	1. Press SYSTEM BLACKOUT button.
__	2. To resume operation, rotate BLACKOUT RESET switch to the RESET position and release (see Figure A7.28).

CHECKLIST 8.16. NORMAL SHUTDOWN PROCEDURES	
__	1. Turn LIGHTING CONTROL switch on control panel to the OFF position.
__	2. At the regulator panel, turn circuit breaker (CB1) to the off (down) position and intensity selector switch (S1) to the OFF position.
__	3. Let generator run for 3 minutes.
__	4. Turn generator off by turning REMOTE START switches on the main control panel to the OFF position. (Step not done on backup control panel.)
__	5. Turn the GENERATOR CONTROL switch on control panel to OFF position.

CHECKLIST 8.17. EMERGENCY SHUTDOWN PROCEDURES	
	Use any **ONE** of the following three procedures.
__	1. At control panel: __ Turn GENERATOR CONTROL switch to OFF position. [Kills generators and all power to the system.] Or, __ Press SYSTEM BLACKOUT button. [Kills lights; generators still run.]
__	2. At regulator panel: __ Turn regulator circuit breaker (CB1) off (down position). [Kills all power to the regulator and lighting circuit.] Or, __ Turn the INTENSITY SELECTOR switch (S1) to the OFF position. [Kills lights; generators still run.]
__	3. At generator: __ Press the EMERGENCY STOP button (kills generator & all system power).

CHECKLIST 8.18. POST INSTALLATION ACTIONS	
__	1. Gather empty containers in one location. Consider reloading and re-securing to the trailers. ***NOTE*:** Be sure containers are dry before closing for storage.
__	2. Fold and store tarps for the regulator and generator trailers in use.
__	3. Move remaining trailers to designated parking locations, close RAC doors, and place tarps back on trailers. ***NOTE*:** Dry wet tarps before folding and storing or before placing on trailers.

CHECKLIST 8.18 continued on next page

CHECKLIST 8.18. POST INSTALLATION ACTIONS	
__	4. Periodically, check all lights and strobes to ensure they are operating. This includes obstruction lights. Also check: __ Angle on DTG marker lights __ Alignment of edge lights and threshold lights __ Cables clear of aircraft movement __ PAPI settings __ Approach lights and strobes aligned with runway/MOS centerline __ Taxiway entrance sweeps __ Ground connections
__	5. Securely anchor light fixtures subjected to jet blasts with stakes (see Attachment 4).
__	6. Harden regulator/control panels and generators if site is subject to attack.
__	7. Mark cable locations when placed in grass that is subject to mowing. Periodically make sure the markers are visible.
__	8. Check cable protection strips for alignment, movement, buckling, damage, and loose cable. Replace damaged or deteriorated sandbags.

WARNING: Always disconnect system power prior to performing maintenance or hazardous voltages capable of causing serious injury or death may be present.

CHECKLIST 8.19. ISOLATING AN OPEN-CIRCUIT IN THE SERIES CIRCUIT	
__	1. Turn power off. Visually check series circuit for open conditions. If found, reconnect or replace faulty cable or transformers. Re-energize the circuit to verify corrective action. **WARNING**: Always account for all team personnel prior to reenergizing system.
__	2. If open is not visible, sectionalize the circuit. __ For safety, disconnect homerun cables from regulator output terminals.

CHECKLIST 8.19 continued on next page

CHECKLIST 8.19. ISOLATING AN OPEN-CIRCUIT IN THE SERIES CIRCUIT	
	__ Disconnect series cable at light fixtures on opposite sides of runway. Pull ends to "middle" of runway and reconnect cables to complete smaller primary circuit. (May use spare runway cable to close circuit across runway.) __ Reconnect homerun cables at regulator and energize to test smaller circuit. If the segment lights up, the omitted part of the circuit contains the open. If the segment does not light, the open is in the tested segment.
__	3. Continue segmenting faulty portion of the circuit and repeat test on ever-smaller segments until finding the open.
__	4. Replace faulty component and retest.

CHECKLIST 8.20. FINDING A SHORT-TO-GROUND IN THE SERIES CIRCUIT	
__	1. Energize to highest intensity setting. Note first and last dimmed lights.
__	2. Inspect for cable/transformer damage between normal and dimmed fixture.
__	3. De-energize circuit and replace faulty component. Account for all team personnel and then reenergize to test the fix.

CHECKLIST 8.21. ON-EQUIPMENT TROUBLESHOOTING

TROUBLE	POSSIBLE CAUSE	REMEDY
Complete loss of lighting	Operator error	At the primary control panel: 1. Verify that either GEN 1 ONLINE or GEN 2 ONLINE indicator light is illuminated. (At backup panel, check single ONLINE light.) 2. Verify that the LIGHTING CONTROL switch is set on LOW, MED, or HIGH. 3. Verify that the system is not "blacked out" by using the BLACKOUT RESET switch.

CHECKLIST 8.21 continued on next page

CHECKLIST 8.21. ON-EQUIPMENT TROUBLESHOOTING

TROUBLE	POSSIBLE CAUSE	REMEDY
Complete loss of lighting (cont.)	No power to regulator	If ONLINE indicator light not illuminated, try bringing one generator online manually. Then try other generator.
	Neither generator working properly	Refer to generator TO.
	Regulator improperly set	At regulator: set intensity selector switch (S1) to the REMOTE position. Ensure circuit breaker (CB1) is ON (up position).
	Control panel not working	Check if system operates using the regulator intensity selector switch (S1).
	Regulator does not turn on using intensity selector switch (S1)	Check input voltage to S1 switch. If voltage present, regulator is bad. Use backup regulator/control panel, or replace or repair regulator. If voltage not present, check cable connections. If cables OK, control panel is bad. Use backup regulator/control panel, or replace or repair control panel.
	Regulator turns on using intensity selector switch (S1) but does not operate remotely from the control panel	1. Properly ground regulator/control panel. 2. Using true-RMS reading voltmeter, check for proper signal input (see system TO). If signal is bad, check connections. If connections are OK, control panel is bad. Use back-up regulator/control panel, or replace/repair control panel.

CHECKLIST 8.21 continued on next page

CHECKLIST 8.21. ON-EQUIPMENT TROUBLESHOOTING

TROUBLE	POSSIBLE CAUSE	REMEDY
Complete loss of lighting (cont.)		3. If signal is good, the regulator is bad. Use backup regulator and control panel, or replace/repair regulator.
	Regulator shut down from open-circuit protection (Open-circuit red LED would be illuminated)	If open-circuit LED (red) is illuminated: 1. Check for proper regulator operation. (See system TO.) 2. If regulator does not work, use backup regulator/control panel or replace/repair regulator. 3. If regulator works, find and repair open circuit in lighting loop (see **Checklist 8.19**).
	Regulator shut down from over-current protection (Over-current red LED illuminated).	If over-current LED (red) is illuminated, the regulator is bad. Use backup regulator and control panel, or replace/repair regulator.
	Regulator repeatedly causes circuit breaker CB1 to trip	Regulator is bad. Use backup regulator/ control panel, or replace or repair regulator.
Loss of >20% of edge, approach, or threshold/ end lights.	Lamp failures	Replace all failed light fixtures. If there are not enough spare light fixtures, replace lamp in failed fixtures.
Loss of PAPI unit	Misaligned PAPI unit	Check for proper aiming of unit.
	Lamp failure	Replace lamp.
	Series circuit adapter failure	Disconnect series circuit adapter (SCA) from PAPI unit. Check output voltage of SCA using a true RMS reading voltmeter. If no voltage is present and runway circuit operates properly, change SCA.

CHECKLIST 8.21 continued on next page

CHECKLIST 8.21. ON-EQUIPMENT TROUBLESHOOTING

TROUBLE	POSSIBLE CAUSE	REMEDY
Loss of PAPI unit (cont.)	PAPI unit failure.	Replace the PAPI unit if it has proper alignment, a good lamp, and the power adapter is functioning properly.
	WARNING: Looking directly into an operating strobe flasher may cause eye damage.	
Complete loss of strobe segment.	Strobe control transmitter or receiver failure	At system control panel, check operation of strobe selector switch. 1. If both strobe segments repeatedly fail to operate, replace control panel. 2. If only one of two strobe segments operate, check failed segment control-timing sequence. If wrong, replace control panel.
	Improper generator frequency	Check frequency at generator control panel. Adjust to 60 Hz using manual speed control.
	WARNING: Capacitors C101 and C102 in strobe unit must be discharged before performing any work inside strobe enclosure or serious injury or death may result.	
	Strobe segment series circuit adapter (SCA) failure	Disconnect SCA from strobe control unit. Check output voltage of SCA using a true-RMS reading voltmeter. If not between 228 VAC and 264 VAC and runway circuit operates properly, change SCA.

CHECKLIST 8.21 continued on next page

CHECKLIST 8.21. ON-EQUIPMENT TROUBLESHOOTING

TROUBLE	POSSIBLE CAUSE	REMEDY
Complete loss of strobe segment (cont.)	Strobe master unit failure	Replace strobe master unit.
Loss of strobe units but not entire segment.	Strobe control unit trigger failure	Check that all of the trigger-LEDs on the strobe control board are illuminating in sequence. If not, replace the strobe master unit or replace the strobe control board in the unit.
	Interlock switch failure	Check for proper operation of interlock switches on failed strobe slave unit. Should have continuity through switches when fully depressed and fully extended. There should be no continuity when in the middle (normal) position. If this is not the case, replace the strobe slave unit or replace the switches.
	Loose cable connections	Tighten cables.
	Failed flash tube	Replace flash tube.
	Failed strobe slave unit	Replace strobe slave unit.
Portion of runway circuit dimming	Multiple shorts to ground	Find and repair runway circuit (see **Checklist 8.20**).

Safety warnings for strobe troubleshooting Checklists 8.22 & 8.23

WARNING: Capacitors C101 & C102 in the strobe unit must be discharged before performing any work inside the strobe enclosure or serious injury or death may result.

WARNING: Looking directly into an operating strobe flasher unit may cause eye damage.

CHECKLIST 8.22. STROBE SLAVE UNIT TROUBLESHOOTING

TROUBLE	POSSIBLE CAUSE	REMEDY
Strobe slave unit does not operate and trigger relay doesn't trigger	Improper input voltage or faulty connections	See system TO.
	Failed interlock switches	See system TO.
	Faulty trigger relay	See system TO.
Strobe slave unit does not operate, but trigger relay does trigger	Flasher unit on/off switch (S104) is in the off position	Move on/off switch to the on position.
	Failed flash tube	Replace flash tube.
	Blown fuse F101 or F102	Check and replace blown fuses.
	Faulty trigger relay	See system TO.
	Fuses F101 or F102 blow repeatedly due to faulty components	Visually inspect components and wiring for signs of damage or loose connections. If no sign of evidence, see system TO.
Strobe slave unit operates, but skips	Faulty flash tube	Replace flash tube.
	Faulty trigger relay	See system TO.

CHECKLIST 8.23. STROBE MASTER UNIT TROUBLESHOOTING

TROUBLE	POSSIBLE CAUSE	REMEDY
Strobe master does not operate locally	Improper input voltage or loose connections	See system TO.
	Blown fuses	Check fuses F101 & F102. Replace if blown.
	Faulty interlock switches	See system TO.
	Faulty power relay	See system TO.
	Faulty control board	See system TO.

CHECKLIST 8.23 continued on next page

CHECKLIST 8.23. STROBE MASTER UNIT TROUBLESHOOTING

TROUBLE	POSSIBLE CAUSE	REMEDY
Strobe master unit operates but does not send power & control signals to all strobe slave units	Loose connections	Check for loose connections.
	Failed trigger output	See system TO.
Strobe master unit operates locally but not remotely	Incorrect strobe segment setting	Ensure that LOCAL-REMOTE-OFF switch is in remote position and that the strobe segment selector switch is set properly.
	Faulty strobe control signals transmitted by the EALS control panel	See system TO.
	Faulty strobe control board	See system TO.

CHECKLIST 8.24. PAPI TROUBLESHOOTING

TROUBLE	POSSIBLE CAUSE	REMEDY
All lights out	Wiring disconnected	Ensure all connections are tight and wiring is in good condition.
	Unit out of alignment	Realign unit.
	Loss of input power	Check for proper input power.
	Circuit malfunction	Troubleshoot circuit (see **Checklists 8.19 & 8.20).**
	Failed time delay or K1 relay	See system TO.
Lamp inoperative	Lamp burned out	Replace lamp.
Lights do not brighten in sunlight	Failed photo cell	Replace photocell.
	Failed K2 relay	See system TO.

CHECKLIST 8.25. CONTROL PANEL TROUBLESHOOTING

TROUBLE	POSSIBLE CAUSE	REMEDY
Failure to provide power to regulator	Loose regulator power input/output connection	Check/reconnect cable assembly connection.
Failure to control runway lights	Blown fuses	Check and replace fuses.
	Loose regulator control output connection	Check/reconnect cable assembly connection.
	Switch failure, wiring fault, or other faulty or loose components	See system TO.
Failure to provide proper control of strobe segments	Strobe control transmitter failure	See system TO.
Indicator light/panel lamp inoperative.	Faulty lamp or wiring.	See system TO.

CHECKLIST 8.26. REGULATOR TROUBLESHOOTING

TROUBLE	POSSIBLE CAUSE	REMEDY
Regulator does not respond to intensity selector switch (S1)	Fuse F1 blown	Check and replace fuses F1 if faulty.
	Faulty component	See system TO.
Regulator does not turn on remotely, but operates using local intensity selector switch S1	Improper input signal	See system TO.
	Blown fuses	Check and replace fuse F4 (on Control PCB) and fuse F5 (on panel) with new ¼-amp slow-blow fuses if necessary.
	Faulty Control PCB	See system TO.

CHECKLIST 8.26 continued on next page

CHECKLIST 8.26. REGULATOR TROUBLESHOOTING

TROUBLE	POSSIBLE CAUSE	REMEDY
Regulator repeatedly causes circuit breaker (CB1) to trip	Faulty feedback transformer T2/main transformer T1	See system TO.
	Faulty SCR1 or Control PCB	See system TO.
Regulator shuts down from over-current protection (red LED lit)	Improper calibration	See system TO.
	Faulty SCR1 or Control PCB	See system TO.
Regulator shuts down from open-circuit protection (red LED lit)	Regulator output is open-circuited	See system TO.
	Contactor K1 is faulty	See system TO.
	Faulty Control PCB	See system TO.
Incorrect output current	Improper calibration	See system TO.
	Faulty Control PCB	See system TO.

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DCS/Installations & Logistics

Attachment 1

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

A1.1. References

FAA Advisory Circular 150/5345-28, *PRECISION APPROACH PATH INDICATOR (PAPI) SYSTEMS*

UFC 5-535-01, *Airfield Lighting Systems*, 17 November 2005

AFI 32-1044, *Visual Air Navigation Systems,* 4 March 1994

TO 35F5-3-17-1, *Lighting System, Airfield, Emergency A/E82U-2*

TO 35C2-3-446-11 *Generator Set, Skid Mounted, Tactical Quiet* (MEP-805A)

A1.2. Abbreviations and Acronyms

AAS—Aircraft Arresting System

DTG—Distance to Go

EALS—Emergency Airfield Lighting System

FAA—Federal Aviation Administration

FOD—Foreign Object Debris

IAW—In Accordance With

IEEE—Institute of Electrical & Electronics Engineers

IFR—Instrument Flight Rules

IL—Isolation Transformer

kW—Kilowatt

LED—Light Emitting Diode

MAJCOM—Major Command

MAAS—Mobile Aircraft Arresting System

MEP—Mobile Electric Power

MOS—Minimum Operating Strip

MPH—Miles Per-Hour
PAPI—Precision Approach Path Indicator
PAR—Parabolic Aluminized Reflector
PCB—Printed Circuit Board
PPE—Personal Protective Equipment
PSI—Pounds Per Square Inch
RAC—Random Access Container
RMS—Root-Mean-Square
RRP—Runway Reference Point
SCA—Series Circuit Adapter
TAG—1-person Installation Team
TCH—Threshold Crossing Height
TO—Technical Order
VAC—Volts, Alternating Current
W—Watts
UFC—Unified Facilities Criteria
UTS—Under Trailer Storage
UXO—Unexploded Ordnance

A1.3. Terms.

Runway (MOS): This is the paved surface used by aircraft to takeoff and land. Since a pilot can land on each surface from two directions (180° apart), each paved surface is really two runways. Runway edge lights and the threshold/end lights outline the lateral and longitudinal limits of the usable surface of the runway. This combined term indicates that the EALS installation is either on a permanent runway, or on a smaller minimum operating strip (MOS). In this handbook, the word "runway" indicates a runway or MOS.

Inboard/Outboard: Describes the placement of an EALS component relative to the runway (or taxiway). View inboard as closer to, and outboard as farther from, the paved surface.

Runway Threshold/End: The *threshold* is the beginning portion of the usable pavement as viewed by the approaching pilot. The runway *end* is the last portion of the usable runway/MOS available to a pilot. Green lights mark the threshold end, and red lights mark the runway end. When the threshold of a runway is co-located with the end of the opposite runway, the threshold/end lights have a split lens with green on one side and red on the other.

Runway End: Runway approach threshold/departure end where an EALS team begins installing the system. END A threshold/end is where TEAM A begins. END B is the opposite threshold/end where TEAM B begins.

Runway Edge: **O**ne of the long sides of the runway/MOS. EDGE A is the side in the clockwise direction from end A. EDGE B is the other side.

Unidirectional Runway: A condition where, for whatever reason, aircraft takeoff and land on the runway in only one direction. If that condition is not temporary, approach lights and strobes are required only at the approach end, and place distance-to-go lights only on the right side of the runway.

Bi-directional Runway: A runway that can support aircraft operations in both directions.

Runway Designation: A two-digit number that designates the magnetic heading of a runway. As viewed from an inbound aircraft, measure the heading of the runway centerline clockwise from magnetic north. Round the compass reading to the nearest 10 degrees, and drop the last digit (a zero). For example, when the magnetic heading of a runway/ MOS is 068°, the runway designation is 07 (round 068 to 070 and drop the last digit). When viewed from the opposite direction, consider the pavement a separate runway, and its designation is 25 (180° in the opposite direc-

tion). Painted designations are normally on ends of runways, but not on a MOS (see Figure A7.2).

Runway Reference Point (RRP): The RRP is the point on the runway centerline where the PAPI visual glide path intersects the runway.

Attachment 2

EQUIPMENT LOCATION ON TRAILERS

TABLE A2.1. CONTENTS OF TRAILER NO. 1

STORAGE POSITION ON TRAILER	*CONTENTS OF CONTAINER*
Under Trailer Storage (UTS) Compartment	250 - taxiway reflector bases
Random Access Container (RAC)	40 - taxiway lights 4 - edge/approach lights 1 - threshold/end light 53 - isolation transformers (45W) 250 - taxiway reflector tops 1 - PAPI aiming device 1 - PAPI photocell 1 - strobe SCA cable 1 - PAPI SCA cable 1 - regulator power cable 1 - regulator control cable 1 - male/male runway cable adapter 1 - female/female runway cable adapter 1 - generator unit power cable 10 - ground rod couplings 5 - ground rod clamps Spare component parts (see list in this attachment)
1 strobe master container	1 - strobe master unit
1 PAPI container	1 - PAPI unit
1 obstruction light/battery container	10 - obstruction lights (with batteries) 23 - spare batteries
Primary control panel	
Regulator	

TABLE A2.2. CONTENTS OF TRAILER NO. 2

STORAGE POSITION ON TRAILER	*CONTENTS OF CONTAINER OR REEL*
UTS	1 - series circuit adapter 13 - cable protector segments 48 - ballast rings 250 - stakes 1 - technical order (TO 35F5-3-17-1)
RAC	56 - edge/approach lights 16 - threshold/end lights 5 - DTG marker lights 55 - isolation transformers (45W) 17 - isolation transformers (100W) 1 - PAPI aiming device 1 - PAPI photocell 3 - strobe flashtubes 2 - strobe SCA cables 1 - PAPI SCA cable 1 - regulator power cable 1 - regulator control cable 2 - male/male runway cable adapters 1 - female/female runway cable adapter 10 - ground rod couplings 5 - ground rod clamps
1 strobe master unit container	1 - strobe master unit
2 PAPI containers	1 - PAPI unit
Cable reel	65 - 200' runway circuit cable segments 20 - 50' runway circuit cables 2 - 200' strobe cables 2 - 125' ground cables 1 - PAPI cable

TABLE A2.3. CONTENTS OF TRAILER NO. 3

STORAGE POSITION ON TRAILER	*CONTENTS OF CONTAINER OR REEL*
UTS	1 - strobe series circuit adapter 144 - ballast rings 230 - stakes 1 - technical order (TO 35F5-3-17-1)
RAC	56 - edge/approach lights 16 - threshold/end lights 5 - DTG marker lights 55 - isolation transformers (45W) 16 - isolation transformers (100W) 1 - PAPI aiming device 1 - PAPI photocell 3 - strobe flashtubes 2 - strobe SCA cables 1 - PAPI SCA cable 1 - regulator power cable 1 - regulator control cable 2 - male/male runway cable adapters 1 - female/female runway cable adapter 10 - ground rod couplings 5 - ground rod clamps
1 strobe master unit container	1 - strobe master unit
2 PAPI containers	1 - PAPI unit
Cable reel	65 - 200' runway circuit cable segments 20 - 50' runway circuit cables 2 - 200' strobe cables 2 - 125' ground cables 1 - PAPI cable

TABLE A2.4. CONTENTS OF TRAILER NO. 4

STORAGE POSITION ON TRAILER	*CONTENTS OF CONTAINER OR REEL*
UTS	52 - cable protector segments 1 - tool box
4 strobe slave unit containers	1 - strobe slave unit in each container
Cable reel	7 - 200' runway circuit cable segments 45 - 50' runway circuit cables 39 - 10' runway circuit cables 4 - 250' generator power cables 1 - 25' generator power cable 4 - 250' generator control cables 2 - 25' generator control adapter cables 1 - 1000' ground cable 5 - 25' ground cable 1 - 200' strobe cable 1 - PAPI cable
Backup control panel	
Regulator	
Spare tire storage box	1 - spare tire 3 - ground rod driving rods 3 - ground rod drivers 20 - ground rod sections 1 - lug wrench 1 - jack 1 - jack handle

TABLE A2.5. CONTENTS OF TRAILER NO. 5

STORAGE POSITION ON TRAILER	*CONTENTS OF CONTAINER*
UTS	2 – series circuit adapter
MEP-805 Generator with remote start kit	
Blackout switch	
Generator unit power cable	
Remote start cable	

TABLE A2.6. CONTENTS OF TRAILER NO. 6

STORAGE POSITION ON TRAILER	*CONTENTS OF CONTAINER*
UTS	1 – series circuit adapter 1 – tool box
MEP-805 Generator with remote start kit	
Blackout switch	
Generator unit power cable	
Remote start cable	

TABLE A2.7. SPARE PARTS IN TRAILER NO. 1

COMPONENTS	*SPARE PART*
Edge/approach light	8 – 45W lamps 2 – clear lens
Threshold/end light	5 – 120W lamps 1 – split red/green lens
Taxiway light	6 – 30W lamps 1 – blue lens
Approach strobes	2 – Flash tubes 5 – fuses (5A) 5 – fuses (0.25A)
PAPI	2 – 200W lamps
Regulator	5 – fuses (2A)
Control panels	5 – fuses (1/4A) 5 – fuses (1A, 250V) 5 – fuses (1A, 500V)
Runway circuit cable	5 – plugs 10 – receptacles
Distance-To-Go (DTG) marker light	1 – 45W, PAR 38 lamps

Attachment 3

TAPE SWEEP CLEAR ZONES

A3.1. Minimum tape sweep area is determined by sighting a straight line from the position of the runway edge sheave to a point of maximum tape payout (990 or 1200 ft) down the centerline in direction of arrestment. Remove lights and cable within this area on both sides of the runway. Repeat process in opposite direction for a bidirectional runway. **Table A3.1** shows approximate light free zone distances for a 990 ft tape payout, with 90/153-ft pendants, and edge lights offset at 0, 5, and 10 ft.

Table A3.1. Light Free Zone Distances.

MOS WIDTH (Feet)	*PENDANT LENGTH* (Feet)	*EDGE LIGHT OFFSET*		
		0-FEET	5-FEET	10-FEET
50	90	550 *	450 *	350 *
50	153	700	650	600
90	90	150	50	0
90	153	450	400	350
150	153**	50	0	0

* Distance from AAS to far edge of tape sweep area (in feet). Round up to nearest 50-ft; interpolate this data for other conditions.

** No numbers are provided for a 90-ft pendant on a 150-ft wide runway; the 90-ft pendant effectively reduces the runway width to 90 ft.

Attachment 4

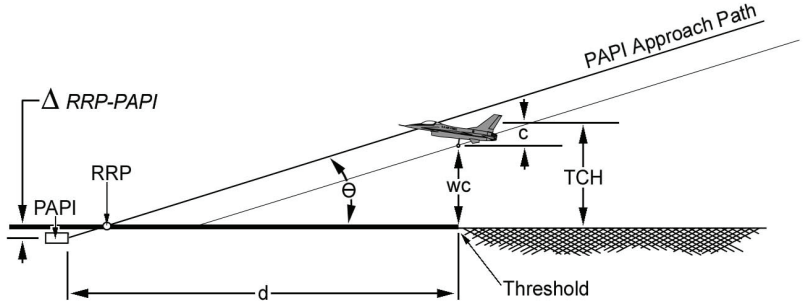
LOCATING THE PAPI LIGHTS

A4.1. Introduction. The Precision Approach Path Indicator is an important element of the Emergency Airfield Lighting System. The pilot of an approaching aircraft depends upon this navigational aid to help safely descend and land on the runway or MOS. The EALS L-881 PAPI system is a two-light system used as a contingency/emergency navigational aid on the airfield to guide aircraft on a predetermined approach path to the runway. Properly located and installed, PAPI lights will guide a pilot onto a runway's touchdown zone, maximizing aircraft rollout and safety margins for protection of both the pilot and the aircraft. Because lives and aircraft are at stake, correctly locating this equipment is critical. The procedures outlined in this attachment are applicable for both an expedient and semi-permanent installation of the PAPI light system. The requirements for siting the PAPI systems are the same for both short-term and long-term use.

A4.2. Basics. The PAPI projects light beams that provide a visual approach path that guides the pilot to the intended touchdown zone on the runway. When on path, the pilot will see red on the inboard unit and white on the outboard unit. The pilot will see red on both units if too low and white if too high (see Figure A4.1). Figure A4.2 illustrates critical elements needed to determine the final PAPI location.

Figure A4.1. PAPI Light Configuration

Figure A4.2. Elements Required to Locate PAPIs



θ -	Angle of approach path (PAPI aiming angle)
RRP -	Runway reference point
d -	Distance from threshold to location of PAPI
TCH -	Threshold crossing height
wc -	Wheel clearance over threshold
c -	Cockpit-to-wheel height
Δ Threshold-RRP -	Elevation difference between the threshold and the runway reference point (RRP) at the centerline of the runway/MOS.
Δ *RRP-PAPI* -	Elevation difference between the RRP and the PAPI location at the centerline of the runway/MOS.

A4.3. Definitions.

A4.3.1. Angle of Visual Approach Path (θ). The angle of the approach path is normally between 2.5° and 4.0°, with 3.0° being the standard. The approach angle may be greater than 4.0° to accommodate local conditions.

A4.3.2. Runway Reference Point (RRP). The RRP is on the runway/MOS centerline where the pilot's line of sight intersects the runway according to the approach glide slope.

A4.3.3. Distance from threshold to location of PAPI (d).The final distance that the PAPI system is located from the threshold after corrections for elevation.

A4.3.4. Threshold Crossing Height (TCH). The pilot's eyes—not the wheels—are on the visual approach path, we must add the height of the pilot above the wheels to the 30-foot wheel clearance height. That combined height is the threshold crossing height (TCH). Obviously, the height of the pilot above the wheels, known as the cockpit-to-wheel height, varies for each aircraft. Aircraft are in one of four height groups, and the height group dictates the threshold crossing height. **Table A4.1** displays the height groups with their corresponding cockpit-to-wheel heights and minimum threshold crossing heights. When determining the location of the PAPI, use the TCH for the largest aircraft height group that routinely uses the runway.

Table A4.1. Visual Threshold Crossing Height Groups

Height Group	Aircraft Type	Approximate Cockpit-To-Wheel Height	Threshold Crossing Height (TCH)
1	T-37, T-38, C-21, T-1, C-12, C-20, & fighter jets	10 ft (3m) or less	40 ft (10 m)
2	F-28, CV-40/440/580, B-737, DC-9/8, C-9/130, T-43, B-2	15 ft (4.5 m)	45 ft (12 m)
3	B-727/707/720/757, KC-135, C-141, C-17, B-52	20 ft (6 m)	50 ft (15 m)
4	B-747/767, L-1011, C-10, A-300, KC-10, C-5, VC-25	Over 25 ft (7.5 m)	75 ft (22 m)

A4.3.5. Cockpit-to-wheel height (c). This is the height of the pilot location above the aircraft wheels.

A4.3.6. Minimum Wheel Clearance over Threshold (wc). While the usable pavement begins at the threshold, we do not want the pilot landing

at or before the threshold if the aircraft comes in too low. To reduce the chance of this happening, the PAPI must be located far enough away from the threshold so the wheels of the landing aircraft are at least 30 feet above the threshold.

A4.3.7. Δ Threshold-RRP. This is the elevation difference between the threshold and the RRP at the runway centerline. Surveyors typically establish this difference. In an emergency, and as a **last resort**, estimate difference with a topographical map or make a visual estimate.

A4.3.8. Δ *RRP-PAPI.* This is the elevation difference between RRP and initial PAPI location at the runway centerline. If the difference is less than 12 inches, consider elevation difference as zero. For an emergency installation and last resort, a person should visually estimate this elevation difference and adjust the threshold to PAPI distance as necessary.

A4.4. Calculating the PAPI Location. Determine the threshold to PAPI distance using the following equation:

$$d = \{TCH + (\Delta \text{ threshold-RRP}) + (\Delta \text{ RRP-PAPI})\} \ (1/\tan \theta)$$

A4.4.1. The first step is to gather information from airfield management. Determine the largest aircraft type expected to use the airfield routinely. In addition, obtain the required aircraft approach angle to the runway.

A4.4.2. Next, determine the RRP by obtaining the TCH from **Table A4.1** and the approach angle multiplying factor from **Table A4.2**. Use this information to fill in the variables of the RRP formula below.

$$RRP = TCH \times 1/\tan \theta$$

Table A4.2. Value of 1/tan θ.

APPROACH SLOPE ANGLE	*1/TAN θ*
2.50°	23
3.00°	19
3.50°	16.3
4.00°	14.3

A4.4.3. Now, determine the initial PAPI location by determining the elevation difference between the threshold and RRP on the runway centerline. If there is no difference, the PAPI location is the same as the RRP. If RRP elevation is higher than the threshold, the initial PAPI location will be closer to the threshold than the RRP, and further from the threshold if the elevation is lower. Use the following formula to determine the initial PAPI location.

$$PAPI = \{TCH - (\Delta RRP - \Delta threshold)\} (1/\tan \theta)$$

Place PAPI lights at increments of 10 feet. If the RRP is ***LOWER*** than the threshold, round ***UP*** to the nearest 10-foot mark from the location derived from the formula. If the RRP is ***HIGHER*** than the threshold, round ***DOWN*** to the nearest 10 foot mark.

A4.4.4. The last variable to fill in the formula is the elevation difference between the RRP and the initial PAPI location at the runway centerline. If the elevations are within 12-inches of each other, consider the elevation difference as zero. Otherwise, fill in the difference in the formula

A4.5. Example Calculations. The following examples show how the different factors influence the location of the PAPI.

A4.5.1. Example 1 – Conditions: The largest aircraft using the runway is a C-17, which is in height group #3 with a TCH of 50 ft. The threshold elevation is 3 feet higher than the RRP, and the PAPI lights are within 12 inches of the RRP. The approach angle is 3°, so 1/tan 3° is 19. Plug the variables into the formula to calculate the threshold to PAPI distance:

$$d = \{TCH + (\Delta threshold - RRP) + (\Delta RRP - PAPI)\} (1/\tan \theta)$$

$$d = \{50 \text{ ft} + (28 \text{ ft} - 25 \text{ ft}) + (25 \text{ ft} - 25'6'')\} (19)$$

$$d = (50 \text{ ft} + 3 \text{ ft} + 0) (19)$$

$$d = 53 \times 19$$

$$d = 1{,}007 \text{ ft} = \text{round up to } \underline{\mathbf{1010 \text{ ft}}}$$

NOTE: In this example, the PAPI and distance-to-go markers would be located in essentially the same place. In this situation, move the distance-to-go marker and light at least 50 ft away from the PAPI.

A4.5.2. Example 2 – Conditions: The largest aircraft is a C-17. The threshold elevation is 3 feet lower than the RRP, and the approach angle is 4°. The calculated threshold to PAPI distance is:

$$d = \{TCH + (\Delta \text{ threshold} - RRP) + (\Delta \text{ RRP} - PAPI)\} (1/\tan \theta)$$

$$d = \{50 \text{ ft} + (25 \text{ ft} - 28 \text{ ft}) + (25 \text{ ft} - 25'6'')\} (14.3)$$

$$d = (50 \text{ ft} - 3 \text{ ft} + 0) (14.3)$$

$$d = 47 \times 14.3$$

$$d = 672.1 \text{ ft} = \text{round down to } \underline{\mathbf{670 \text{ ft}}}$$

A4.6. PAPI Installation. The PAPI lights will be installed on the pilot's left during approach. Install the inboard assembly 50-feet from the left edge of the runway and the outboard assembly 75-feet from the edge of the runway.

A4.6.1. Setup survey instrument over the PAPI location, point "p," and back sight to the threshold centerline, point "t."

A4.6.2. Turn the instrument 90 degrees to the right and place a stake (ip) 50 feet from the left edge of the runway. This is the front and center of the inboard PAPI light. Place another stake (op)" 75 feet from left edge of the runway. This is the front and center of the outboard PAPI light (see Figure A4.3).

A4.6.3. Place 36 to 48-inch guide stakes 10-foot on both sides of stakes "ip" and "op." Use these stakes to ensure PAPI lights are parallel to the runway centerline, and to maintain vertical control. Setup the instrument over stake "ip" and back sight to point "p". Turn right 90 degrees and place a guide stake 10-foot along the line of sight. Plunge scope and place a guide stake 10 foot along line of sight (see Figure 4.4).

A4.6.4. Repeat same steps to place outboard PAPI light guide stakes.

A4.6.5. The lenses of both PAPI lights have to be within one inch of the RRP elevation. Transfer RRP elevation to the guide stakes, minus nine inches. The nine-inch difference represents the distance between the PAPI base and the center of the light lenses.

Figure A4.3. Placing Inboard and Outboard PAPI Stakes.

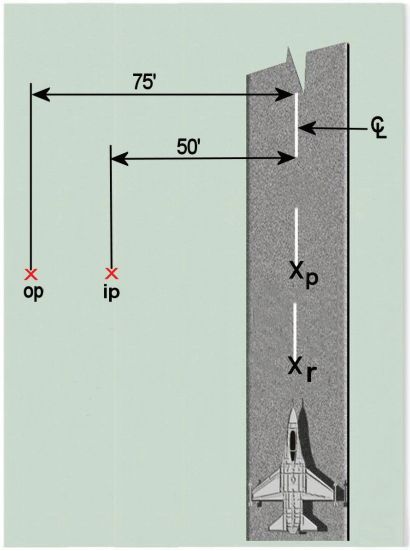
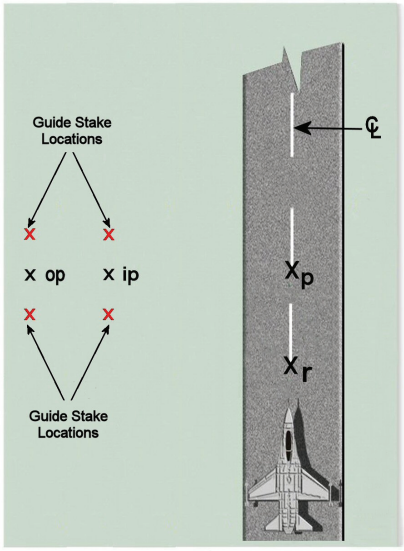


Figure A4.4. Guide Stake Locations.



A4.6.6. When adjusted elevations have been established on guide stakes, stretch a string between the "ip" and "op" guide stakes, and build a platform, or back fill with earth, to elevation of the string (see Figure A4.5).

A4.6.7. Perform these same steps for both inboard and outboard units.

A4.6.8. The next step is to place the PAPI lights exactly at the adjusted PAPI distance from the threshold. Setup the instrument over point "p" and back sight to point "t", and then turn 90 degrees to the right. Center the PAPI on the string so that the center rivet is on the vertical cross hair (see Figure A4.6).

A4.6.9. Accomplish these steps for both the inboard and outboard PAPI units, and then anchor the bases. The installation is now complete.

Figure A4.5. Establishing PAPI Unit Installation Elevation.

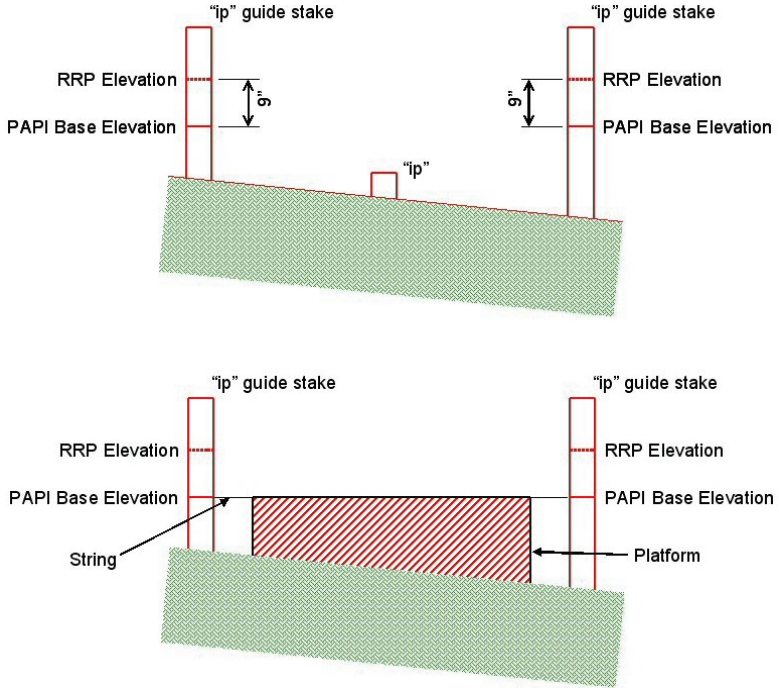
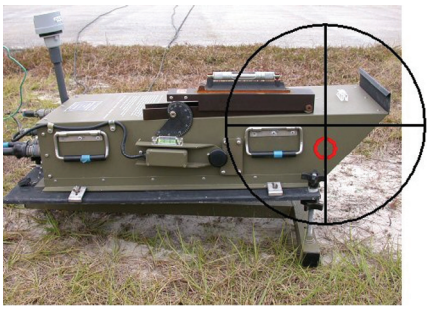


Figure A4.6. PAPI Unit Alignment.

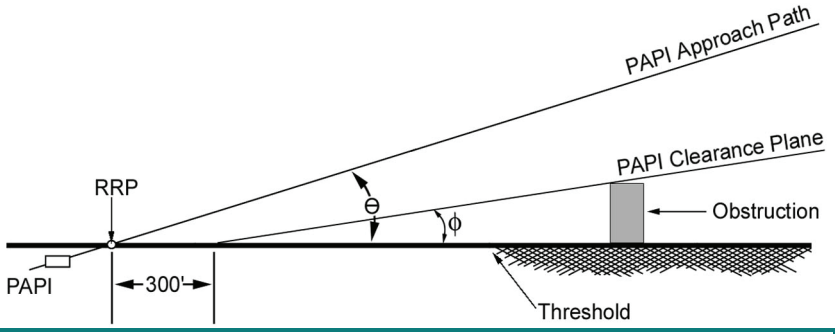


A4.7. PAPI Clearance Plane. For normal conditions, the PAPI must also be located so that no obstructions penetrate the PAPI clearance plane. That plane begins at a point 300 ft downwind (closer to the threshold) from the RRP. The aiming angle for the PAPI glide path shall be not less than 1.2° above the PAPI clearance plane. Figure A4.7 illustrates these details.

A4.7.1. Common obstructions include tall buildings, trees, towers, and land elevations. Clearance plane obstructions will not be a problem when using a previously established approach angle of a pre-existing runway.

A4.7.2. When required, establish a PAPI clearance plane following the instructions in UFC 5-535-01, *Airfield Lighting Systems*. The CE Engineering technicians should do this with support from Airfield Management.

Figure A4.7. PAPI Clearance Plane



θ - Angle of approach path (PAPI aiming angle)
ϕ - Angle of PAPI clearance plane (at least 1.2° less than θ)

A4.8. PAPI Location for an Emergency Installation. For an emergency installation of the EALS, others should mark the proper location of the PAPI system. If not, estimate the elevation differences and make quick calculations as described above.

A4.8.1. An alternative approach is to set the PAPI units 950 feet from the threshold and adjust their location to account for the elevation difference

between the lights and the RRP. This approach assumes no elevation difference between the threshold and the RRP. ***NOTE***: The EALS technical order uses a 950-foot threshold to PAPI distance. That is the optimum distance for a 50-ft TCH, a 3° approach angle, and no elevation difference between the threshold and the beam center of the PAPI lights.

A4.8.2. **Table A4.3** provides the required distances to move the PAPI units away from the threshold when it is necessary to install them more than 12 inches above, or below, the RRP elevation.

Table A4.3. Crown Height Elevation Adjustment.

Elevation Difference in Feet (Crown Higher Than PAPI)	*Displacement Distance in Feet Away From the Threshold**
1	20
2	40
3	60
4	75
5	100
8	150
10	200
* Based on 3° approach angle, which yields a 1/tan θ value of 19. This table rounds that value to 20.	

A4.9. Sources of Information. The information for this attachment comes from UFC 5-353-01 and FAA Advisory Circular 150/5345-28, PRECISION APPROACH PATH INDICATOR (PAPI) SYSTEMS.

Attachment 5

LIGHT FIXTURE STAKING PROCEDURES

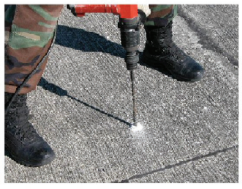
A5.1. Staking Process. Perform the following procedures to securely anchor light fixtures on concrete/asphalt in areas susceptible to high jet blasts. Ballast rings were inadequate in these areas.

STEP 1

A5.1.1. Place the light fixture on the surface at the installation location. Ensure the isolation transformer is facing in the appropriate direction. Place a stake in the hole of the fixture base and tap it with hammer to make a mark on the pavement (Figure A5.1, Step 1).

A5.1.2. Place the light fixture aside and drill a hole where the mark just made. The hole should be just smaller than, or the same diameter as, the anchor stake (Figure A5.1, Step 2).

STEP 2



A5.1.3. Reposition light over the hole and hammer an anchor stake halfway into hole (Figure A5.1, Step 3).

A5.1.4. Now, make a mark for the second stake as described in paragraph A4.1.1 (Figure A5.2, Step 4).

A5.1.5. Swing the fixture out of the way and drill the second hole (Figure A5.2, Step 5).

STEP 3

A5.1.6. Reposition the fixture and drive both stakes into the holes until the heads are just above the base. Be careful not to damage the fixture (Figure A5.2, Step 6).

Figure A5.2. Light Fixture Staking Procedures, Steps 4 thru 6.

Attachment 6

PAPI TILT SWITCH ADJUSTMENT

A6.1. Purpose. The bubble on the tilt switch is not always accurate and sometimes difficult to judge. It is best to verify the adjustment using a meter. Use the following steps to accurately adjust the tilt switch.

Figure A6.1. Tilt Switch Adjustment, Steps 1 - 3.

STEP 1

STEP 2

STEP 3

A6.1.1. Disconnect the tilt switch cannon plug from the rear of the PAPI unit (Figure A6.1, Step 1).

A6.1.2. Loosen the tilt switch adjustment knob on the side of the PAPI unit (Figure A6.1, Step 2).

A6.1.3. Place the ohmmeter leads across the cannon plug pins to check for continuity (Figure A6.1, Step 3).

A6.1.4. Raise and lower tilt switch until the ohm-meter indicates continuity (Figure A6.2, Step 4).

A6.1.5. Tighten adjustment knob on the tilt switch while indicating continuity (Figure A6.2, Step 5).

A6.1.6. Reconnect the cannon plug to the rear of the PAPI unit (Figure A6.2, Step 6).

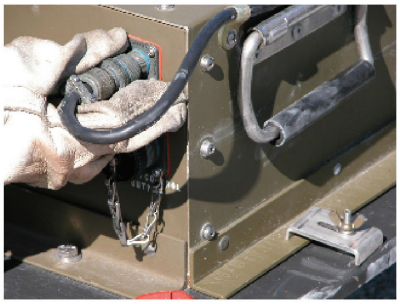
A6.1.7. Repeat steps 1 thru 6 on the second PAPI unit (Figure A6.2, Step 7).

Figure A6.2. Tilt Switch Adjustment, Steps 4 thru 7.

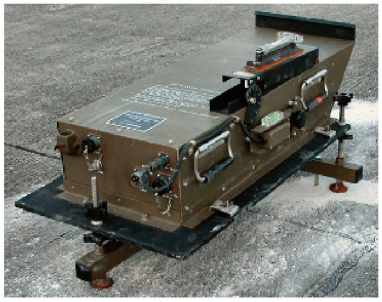
STEP 4

STEP 5

STEP 6



STEP 7



Attachment 7

SUPPORTING GRAPHICS

Figure A7.1 Terms Relating to the Runway/MOS.

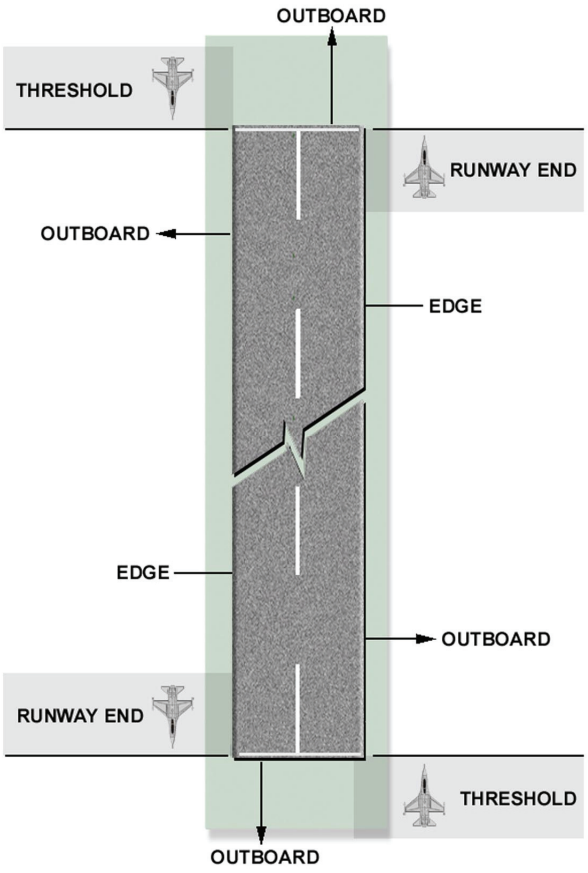


Figure A7.2. Runway/MOS Orientation and Designation.

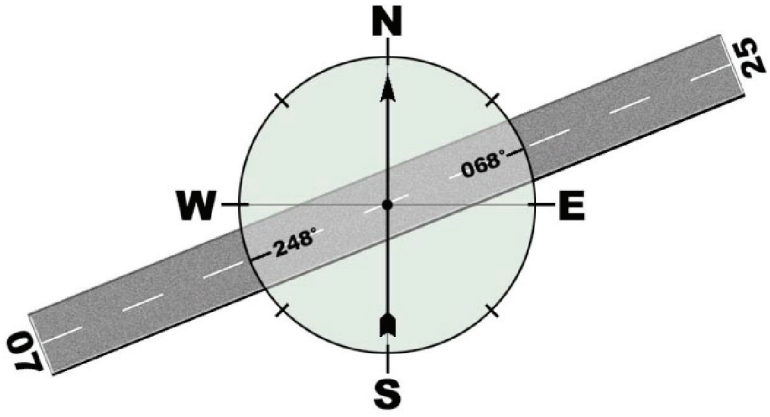


Figure A7.3. Edge Light Placement.

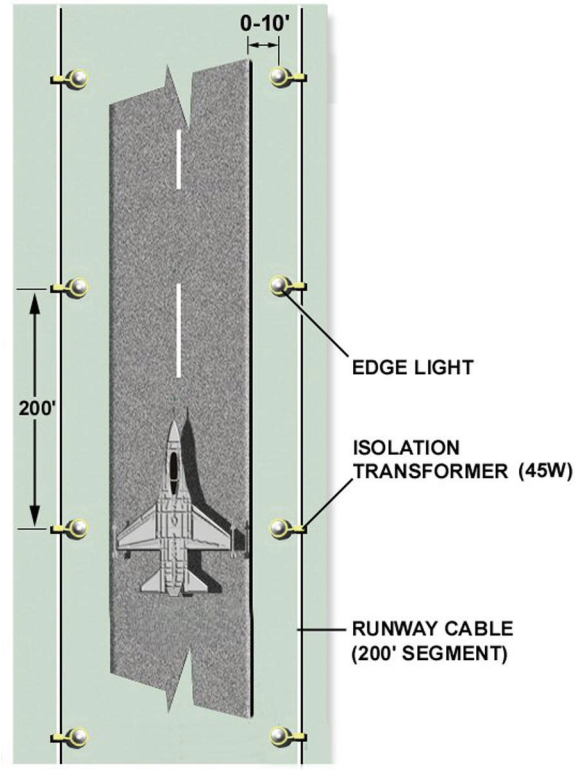


Figure A7.4. Threshold Light Placement.

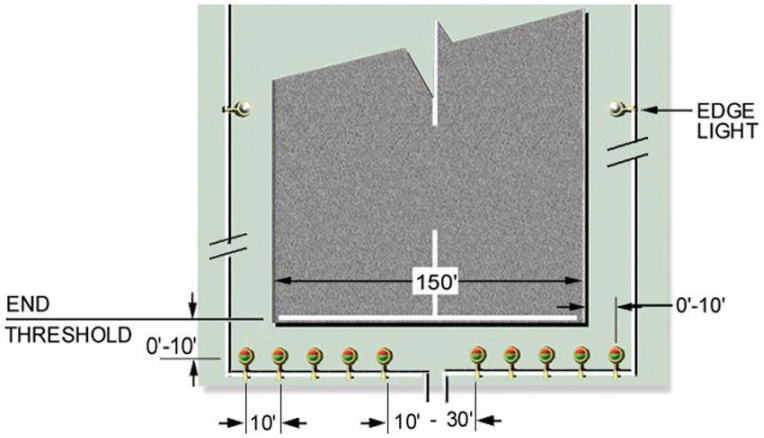


Figure A7.5. Approach Light Placement.

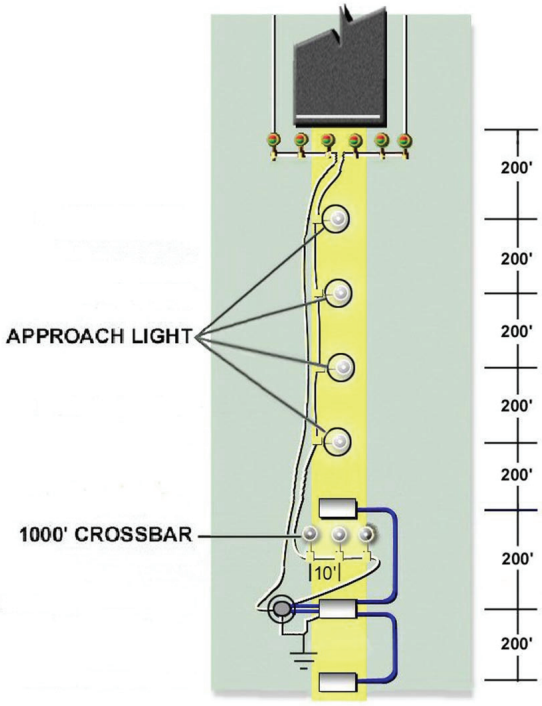


Figure A7.6. Strobe Light Placement.

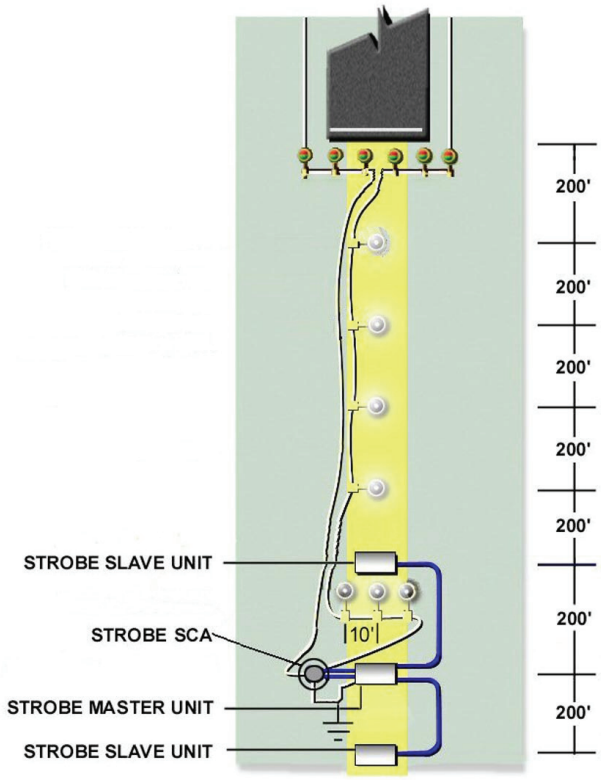


Figure A7.7. PAPI Light Placement.

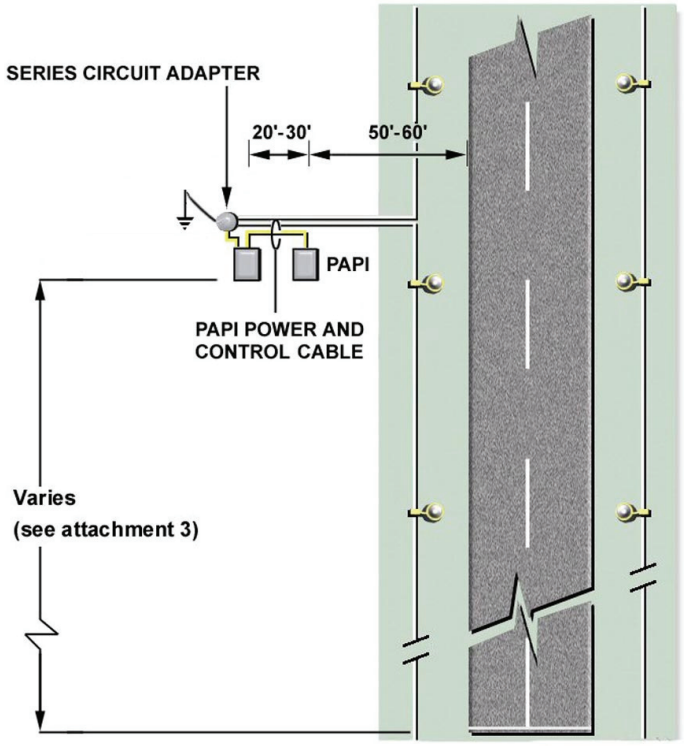


Figure A7.8. Distance-to-Go & AAS Marker Light Placement.

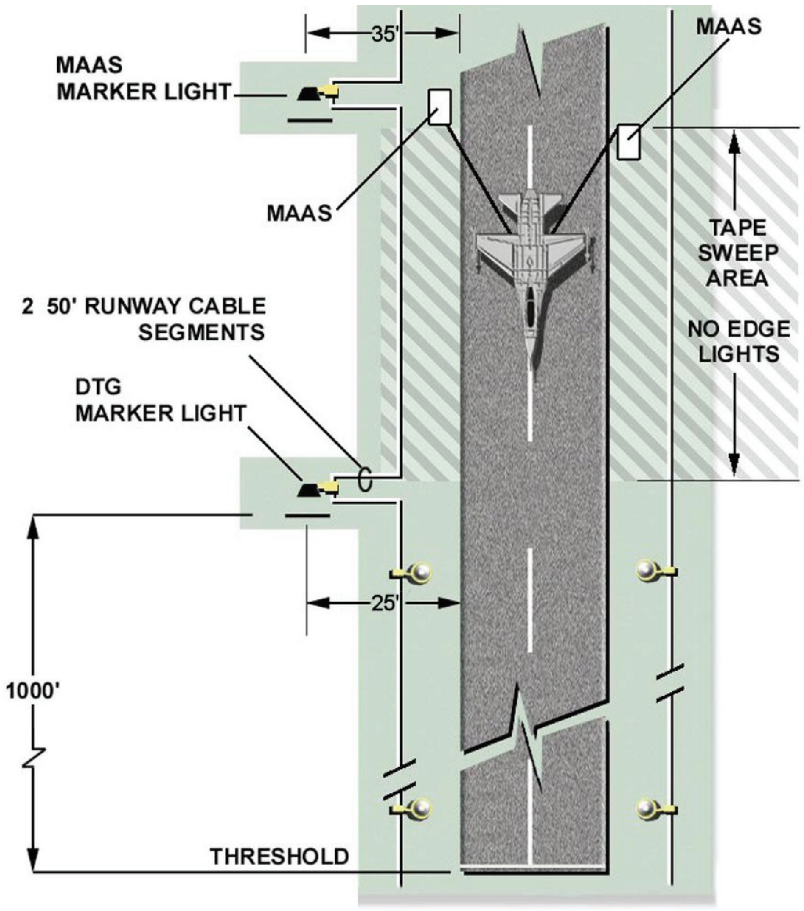


Figure A7.9. Taxiway Light Placement.

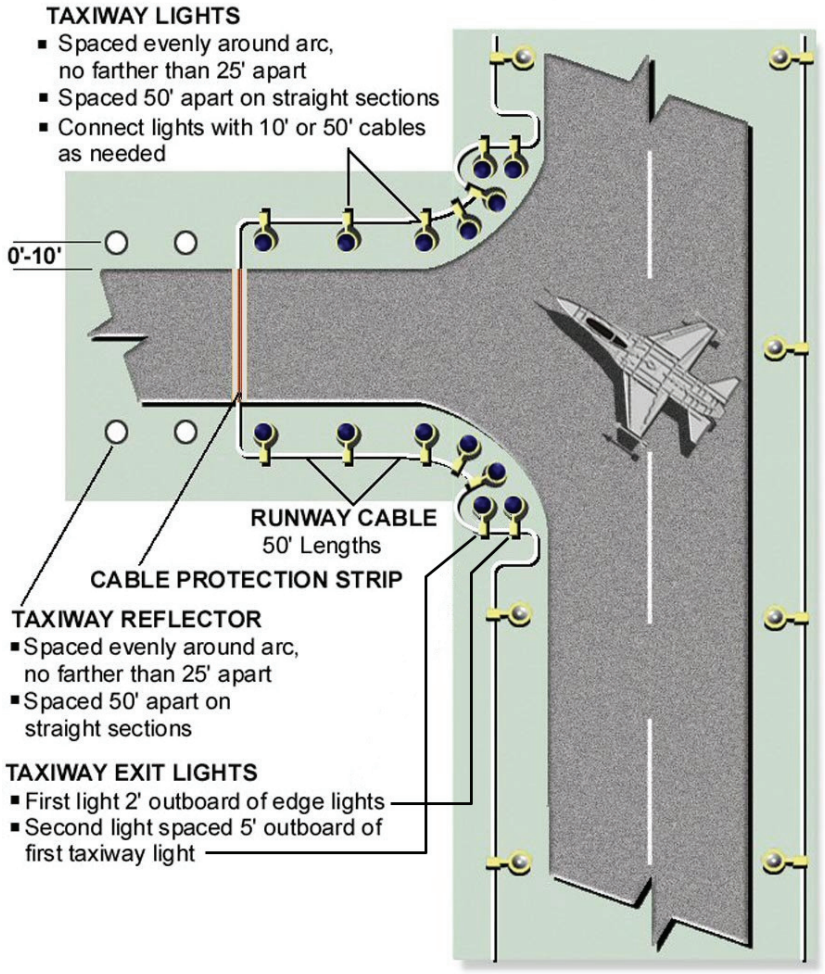


Figure A7.10. Generator and Regulator Placement.

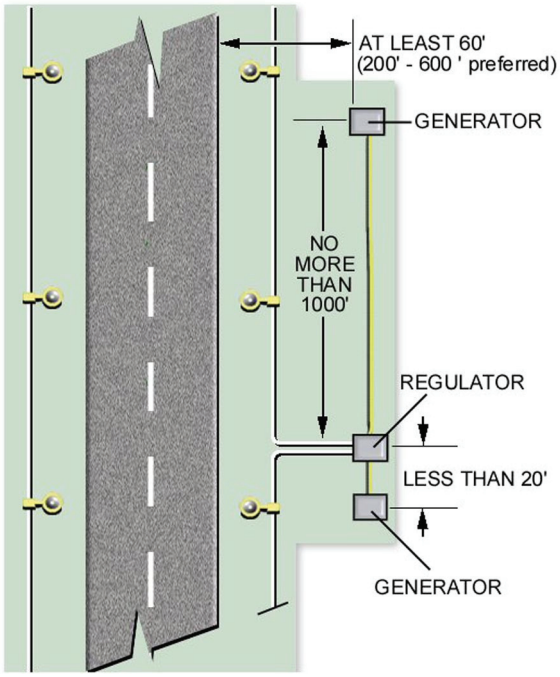
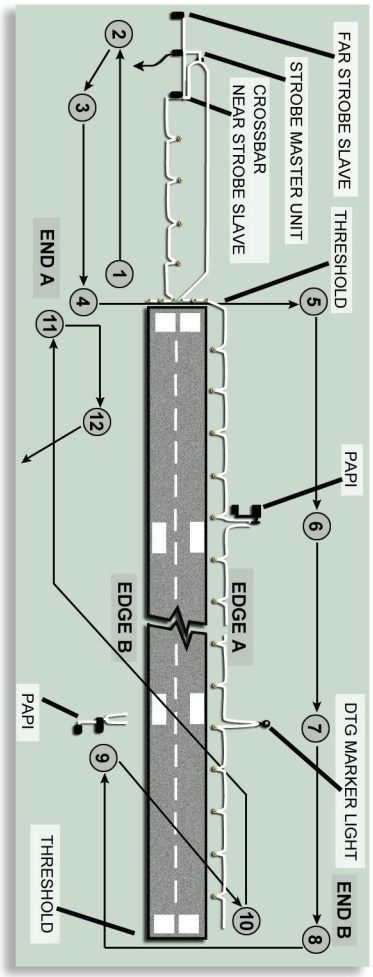


Figure A7.11. Team A MOS Installation Route.



(1) PAYOUT 200 ft. RUNWAY CABLE SEGMENTS FROM THE THRESHOLD TO THE STROBE MASTER UNIT LOCATION.

(2) DROP OFF TAG A AND PLACE END A STROBE SEGMENT.

(3) PLACE END A APPROACH LIGHTS, TRANSFORMERS AND 200 ft. RUNWAY CABLE SEGMENTS.

(4) PLACE END A THRESHOLD/END LIGHTS, TRANSFORMERS, AND 200 ft. RUNWAY CABLE SEGMENTS.

(5) PLACE EDGE A LIGHT FIXTURES, TRANSFORMERS, AND RUNWAY CABLE SEGMENTS.

(6) INSTALL EDGE A PAPI.

(7) AT DTG MARKER LIGHT LOCATIONS, PLACE THE DTG MARKER LIGHTS, TRANSFORMERS, AND 50 ft. RUNWAY CABLE SEGMENTS

(8) ONCE REACHING END B THRESHOLD, DRIVE TO EDGE B PAPI LOCATION

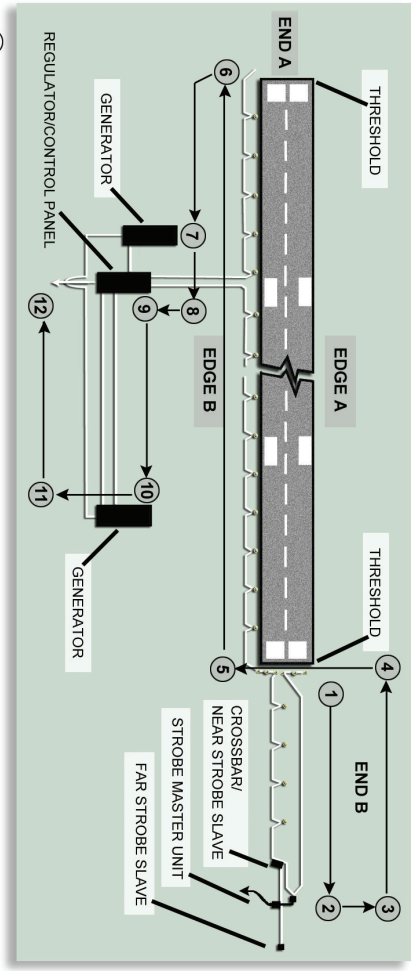
(9) PLACE AND INSTALL EDGE B PAPI AND DRIVE BACK TO END B THRESHOLD.

(10) DRIVE ALONG EDGE A FROM END B TOWARD END A AND INSTALL LIGHT FIXTURES, DTG MARKER LIGHTS, AND TRANSFORMERS UNTIL MEETING UP WITH TAG A. DRIVE TO END A THRESHOLD.

(11) DRIVE ALONG EDGE B FROM END A TOWARD END B UNTIL MEETING UP WITH TAG B.

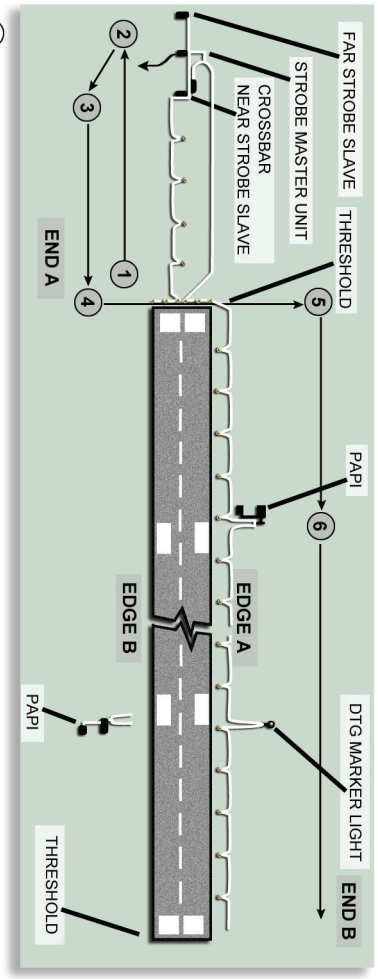
(12) DRIVE TO REGULATOR LOCATION.

Figure A7.12. Team B MOS Installation Route.



1. PAYOUT 200 ft. RUNWAY CABLE SEGMENTS FROM THE THRESHOLD TO THE STROBE MASTER UNIT LOCATION.
2. DROP OFF TAG B AND PLACE END B STROBE SEGMENT.
3. PLACE END B APPROACH LIGHTS, TRANSFORMERS AND 200 ft. RUNWAY CABLE SEGMENTS.
4. PLACE END B THRESHOLD/END LIGHTS, TRANSFORMERS, AND 200 ft. RUNWAY CABLE SEGMENTS.
5. PLACE EDGE B LIGHT FIXTURES, TRANSFORMERS, AND RUNWAY CABLE SEGMENTS.
6. ONCE REACHING END B THRESHOLD, DRIVE TO REGULATOR LOCATION
7. PLACE 200 ft. RUNWAY CABLE SEGMENTS FROM REGULATOR TO RUNWAY EDGE AND BACK.
8. INSTALL FIRST GENERATOR.
9. PAY OUT GENERATOR POWER CABLE FROM CONTROL PANEL TO SECOND GENERATOR SITE.
10. INSTALL SECOND GENERATOR
11. PAY OUT GENERATOR CONTROL CABLE FROM SECOND GENERATOR SITE TO CONTROL PANEL. GO BACK TO SECOND GENERATOR AND PAY OUT GROUND CABLE TO CONTROL PANEL.
12. MAKE ALL ELECTRICAL CONNECTIONS AT REGULATOR CONTROL PANEL LOCATION.

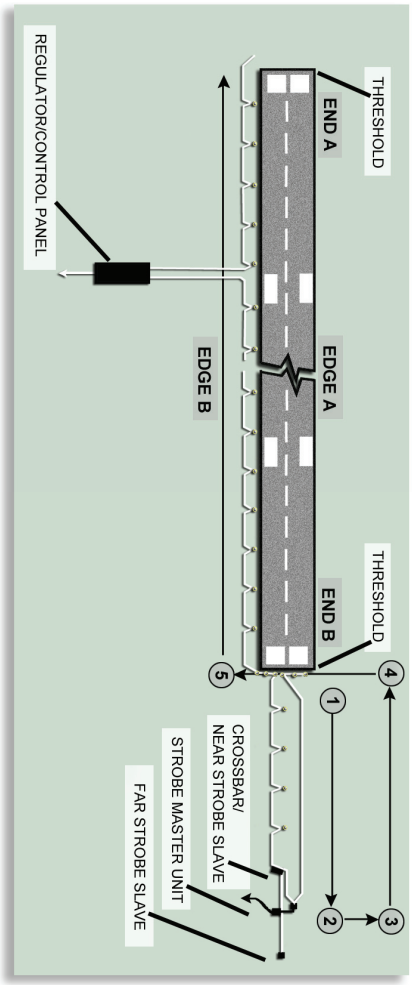
Figure A7.13. TAG A MOS Installation Route.



1. PAYOUT 200 ft. RUNWAY CABLE SEGMENTS FROM THE THRESHOLD TO THE STROBE MASTER UNIT LOCATION.
2. INSTALL END A STROBE SEGMENT.
3. INSTALL END A APPROACH LIGHTS AND TRANSFORMERS
4. INSTALL END A THRESHOLD/END LIGHTS AND TRANSFORMERS.
5. INSTALL EDGE A LIGHT FIXTURES AND TRANSFORMERS TO END B THRESHOLD.
6. ADD DTG MARKER LIGHT LOCATIONS. INSTALL THE DTG MARKER LIGHTS AND TRANSFORMERS.

NOTE: TEAM A WILL BE INSTALLING EDGE A LIGHT FIXTURES FROM END B TOWARD END A. UPON MEETING WITH TEAM A PROCEED WITH TEAM A FOR THE DURATION OF THE INSTALLATION.

Figure A7.14. TAG B MOS Installation Route.



1. PAYOUT 200 ft. RUNWAY CABLE SEGMENTS FROM THE THRESHOLD TO THE STROBE CONTROL UNIT LOCATION WHILE RIDING WITH TEAM B
2. INSTALL END B STROBE SEGMENT.
3. INSTALL END B APPROACH LIGHTS AND TRANSFORMERS.
4. INSTALL END B THRESHOLD/END LIGHTS AND TRANSFORMERS.
5. INSTALL EDGE B LIGHT FIXTURES AND TRANSFORMERS TOWARD END A.

NOTE: TEAM A WILL BE INSTALLING LIGHT FIXTURES AND TRANSFORMERS ALONG EDGE B FROM END A TOWARD END B. UPON MEETING UP WITH TEAM A, PROCEED WITH TEAM A TO REGULATOR/CONTROL PANEL LOCATION.

Figure A7.15. Cable Rewind Instructions below Cable Reel

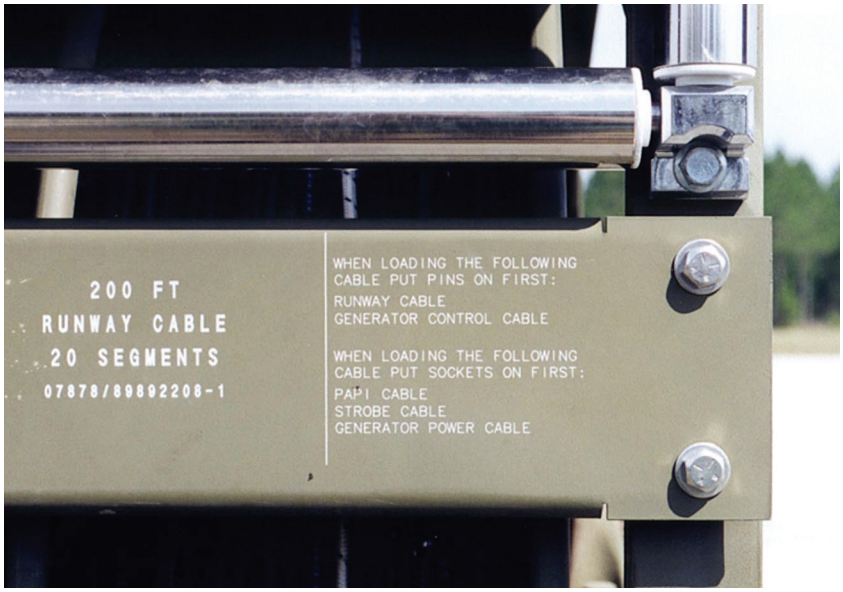


Figure A7.16. Shorting Strobe Capacitors.

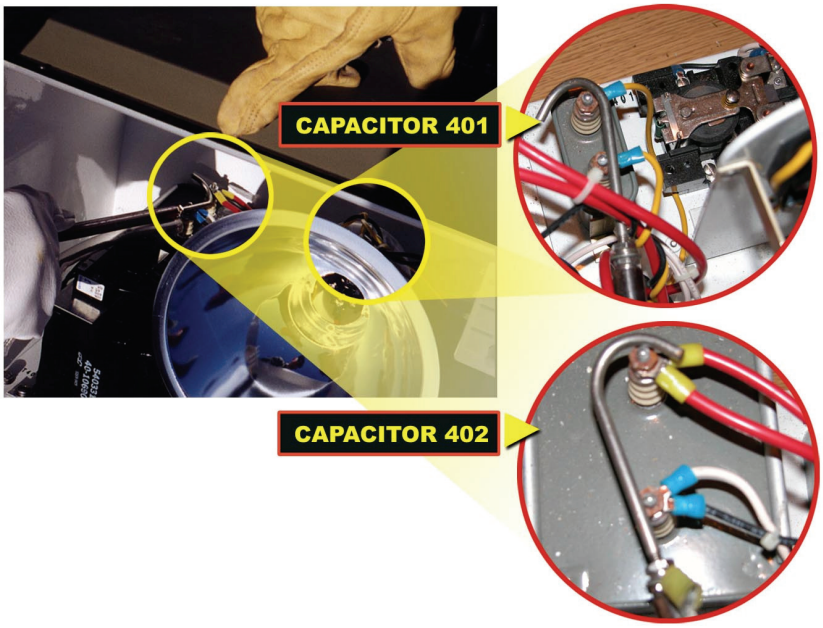


Figure A7.17. Strobe Unit ON-OFF Switch.

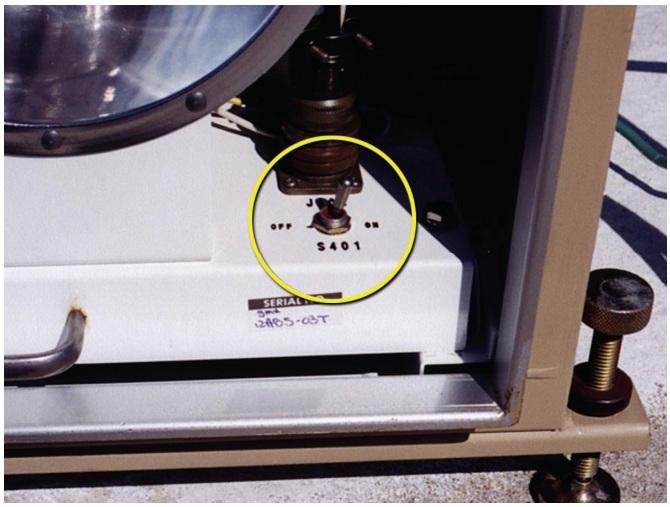


Figure A7-18. Remote OFF-ON Switch and Segment Selector Switch.

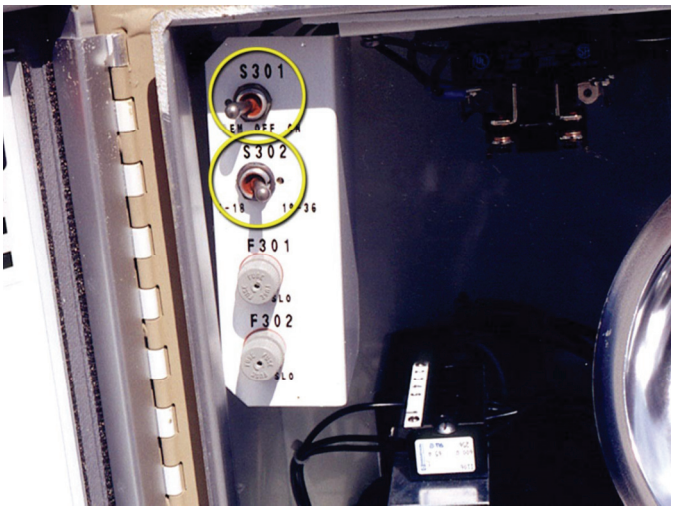


Figure A7.19. SCA Primary Cable Connections.

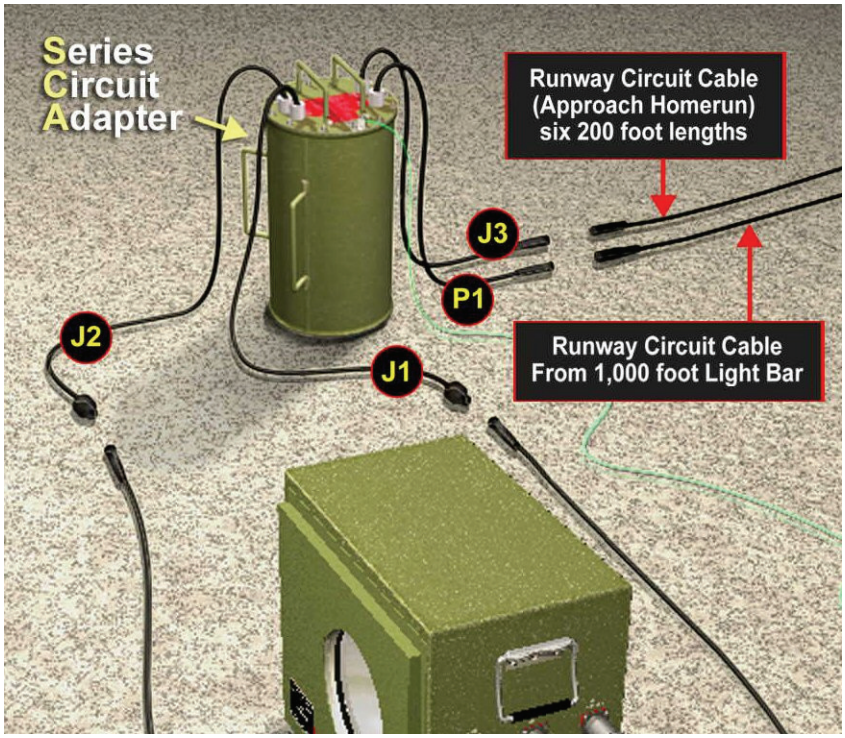


Figure A7.20. Cable Connections at Strobe Master.

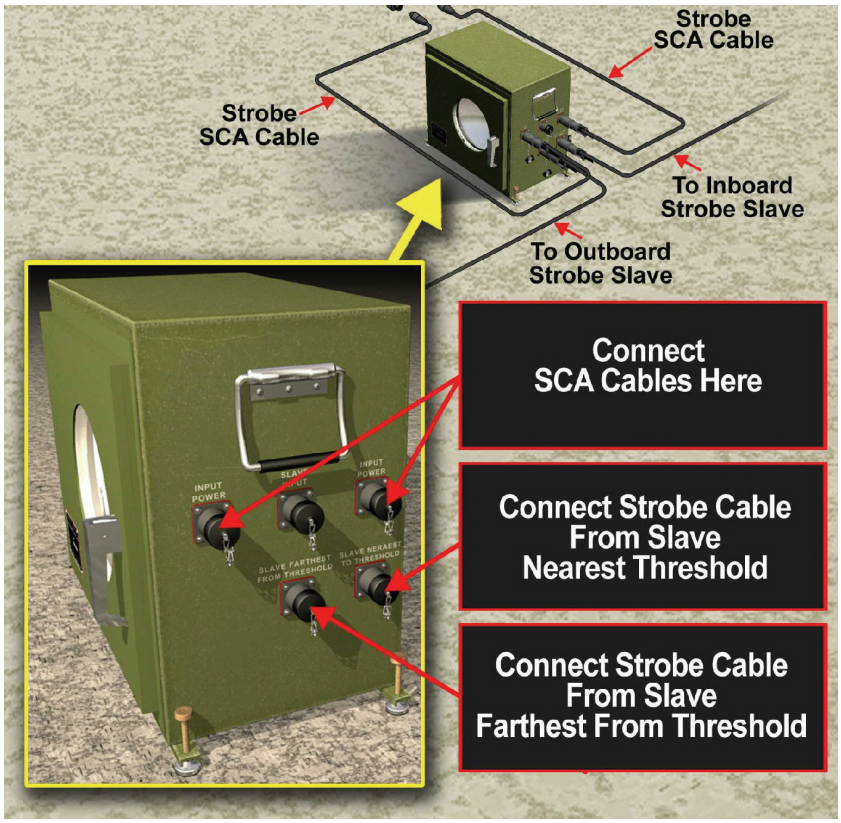


Figure A7.21. Approach Cross Bar.

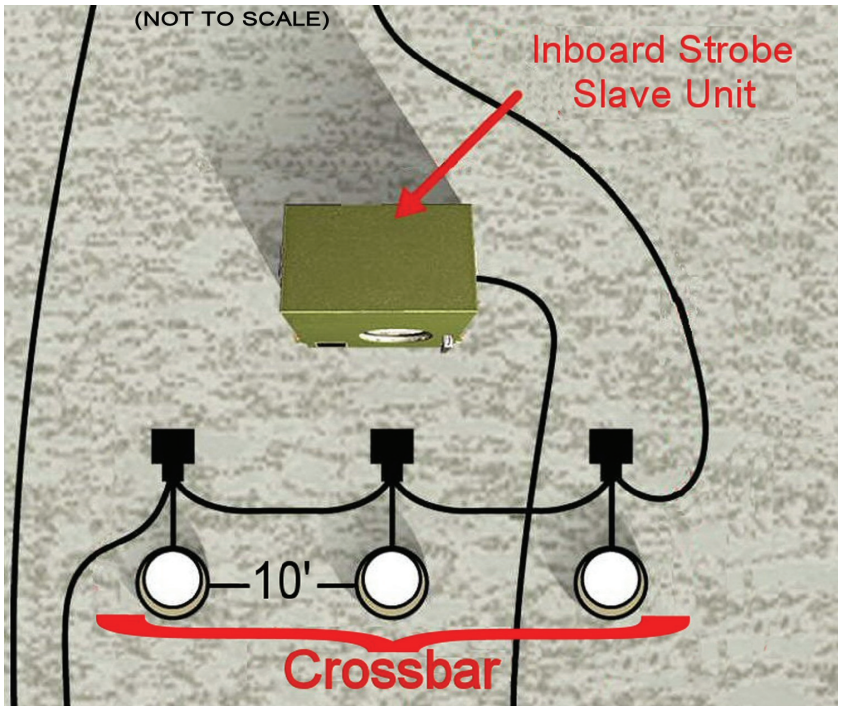


Figure A7.22. Tilt Switch and Photo Cell Connections.

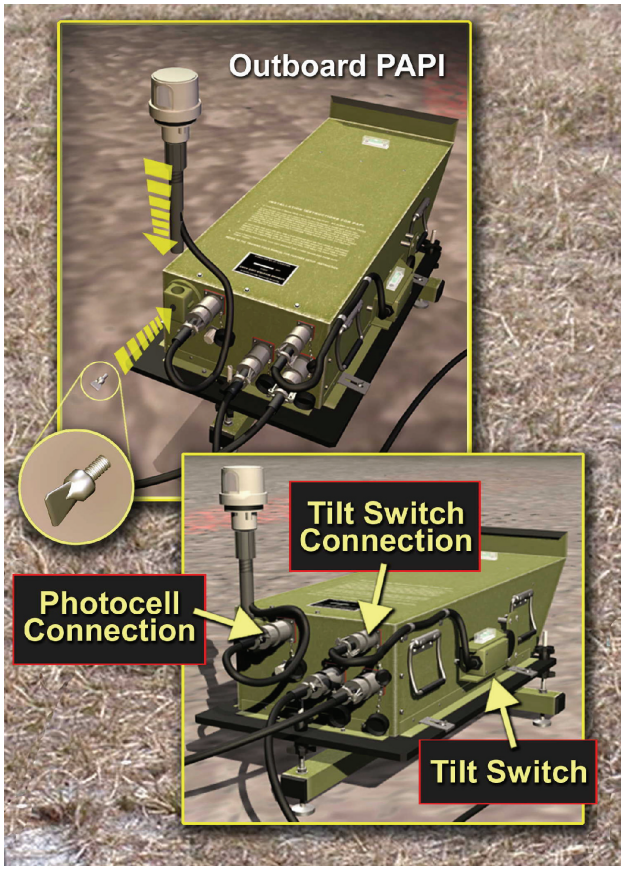


Figure A7.23. Outboard PAPI and Series Circuit Adapter.

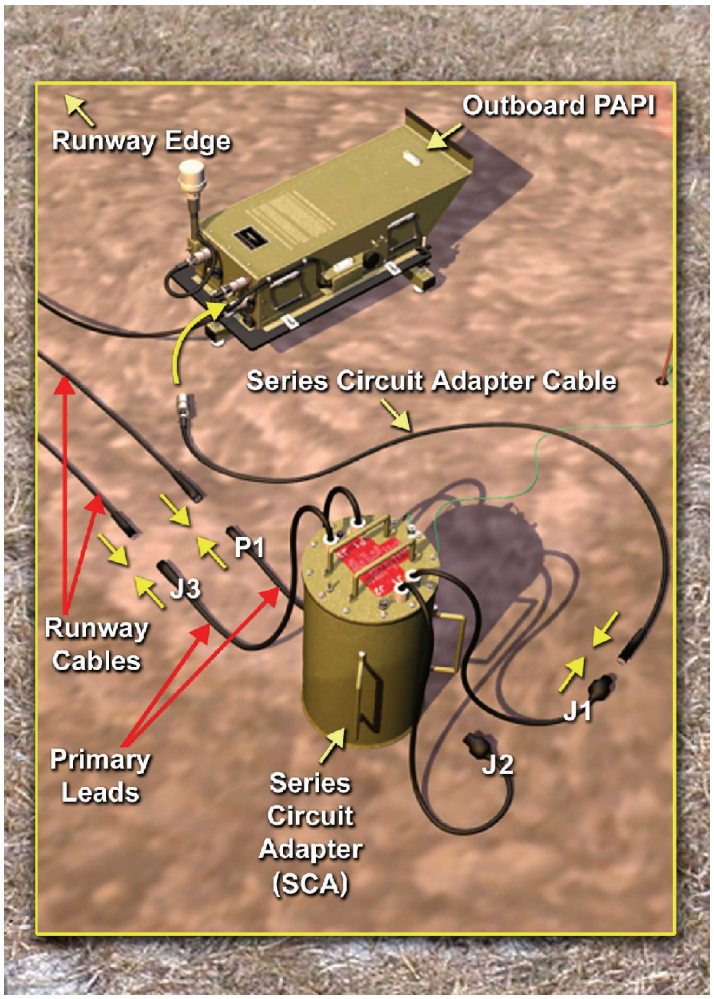


Figure A7.24. SCA and PAPI Connections.

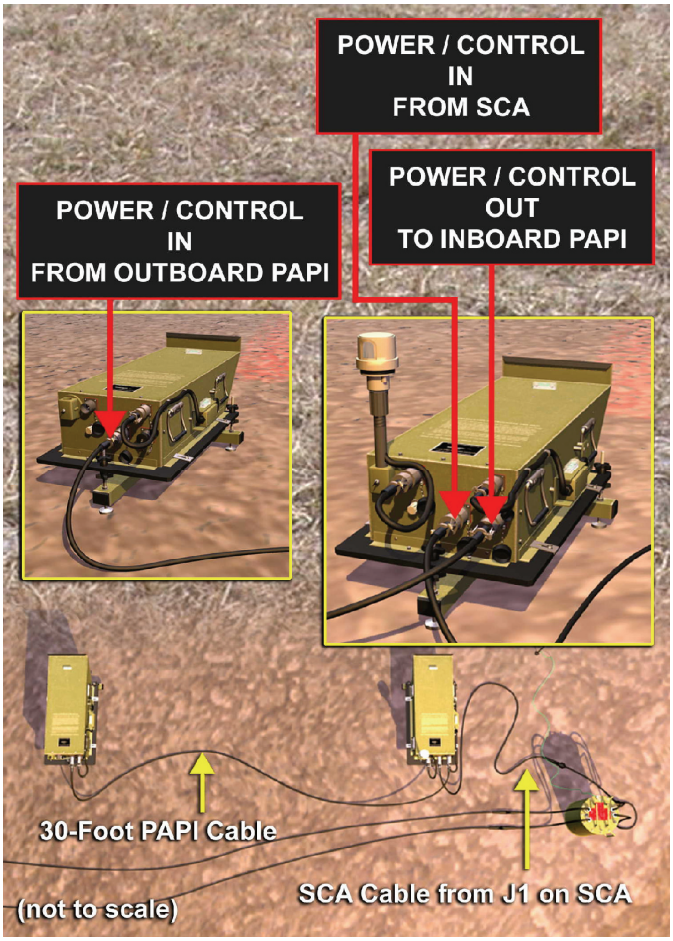


Figure A7.25. PAPI Aiming Device.

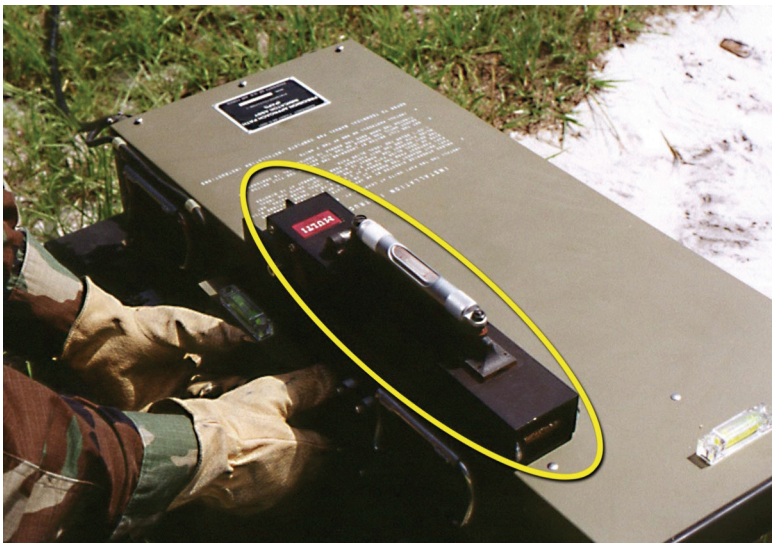


Figure A7.26. Taxiway Cable Protection Strips.

Figure A7.27. Inserting Cable in Cable Protection Strip.

Figure A7.28. Primary Control Panel (Trailer #1).

Figure A7.29. Backup Control Panel (Trailer #4)

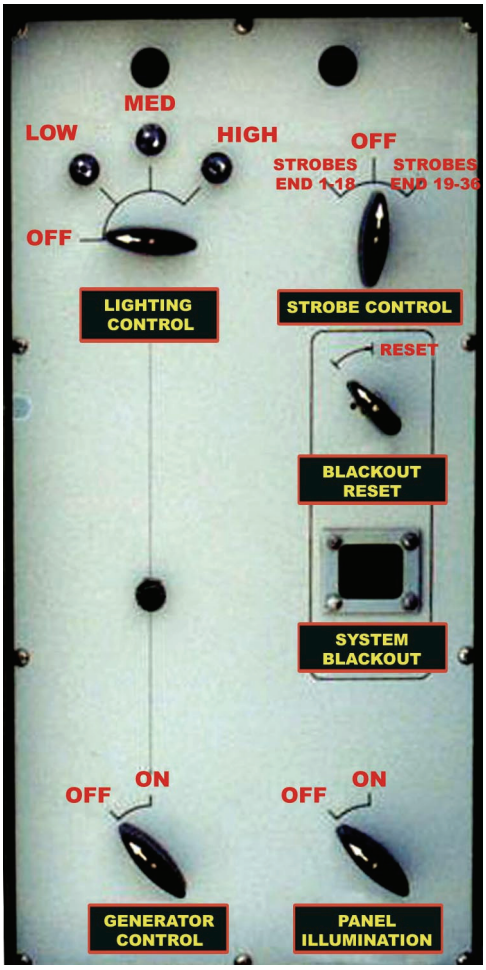


Figure A7.30. Regulator Ground.

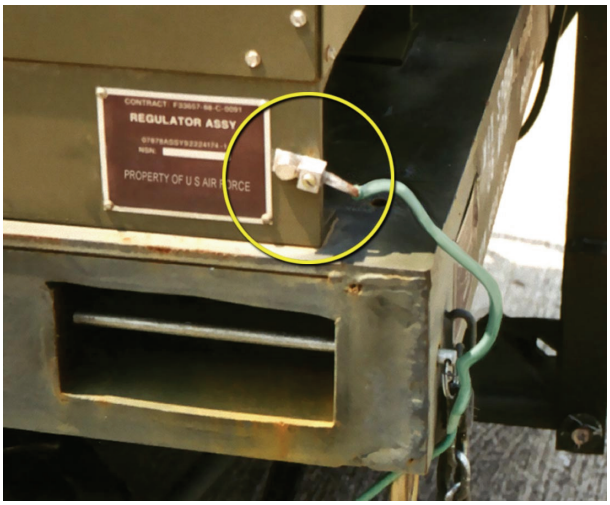


Figure A7-31. Control Panel Ground.

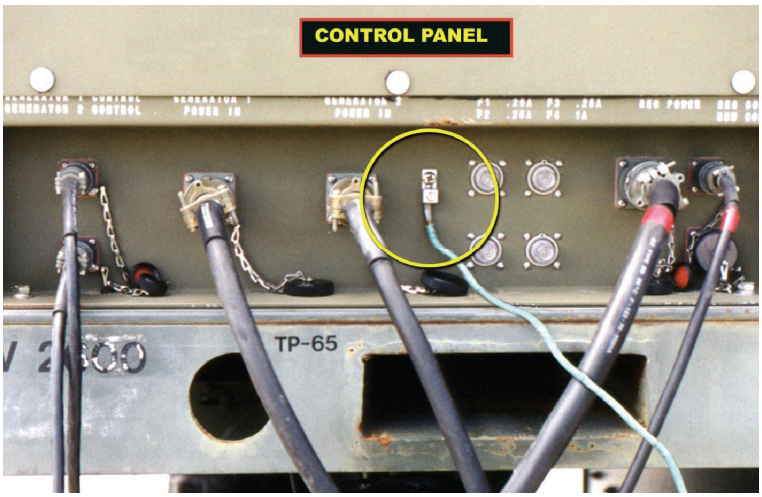


Figure A7.32. Generator Unit Power Cable Connection to Generator.

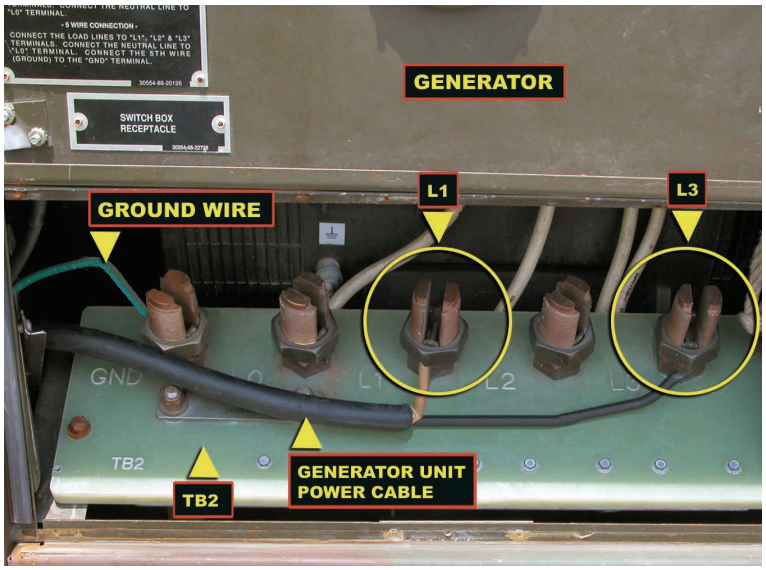


Figure A7.33. Gen. Power and Gen. Power Unit cable Connections.

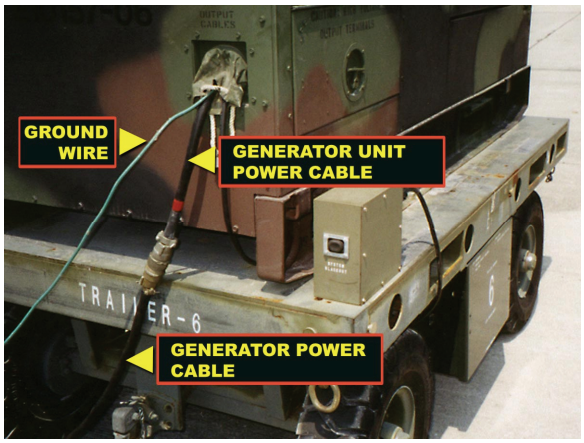


Figure A7-34. Generator Control Cable Connection to Generator.

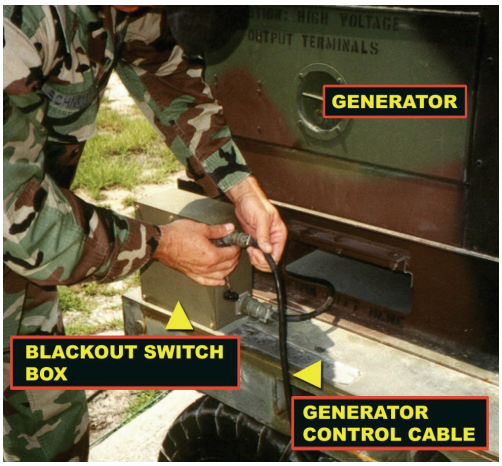


Figure A7-35. Cable Connections at Control Panel.

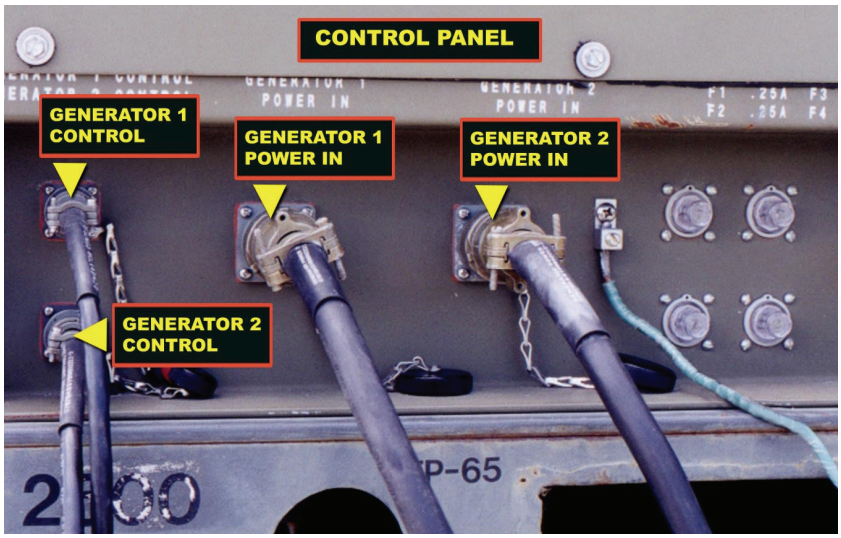


Figure A7.36. Cable Connections from Control Panel to Regulator.

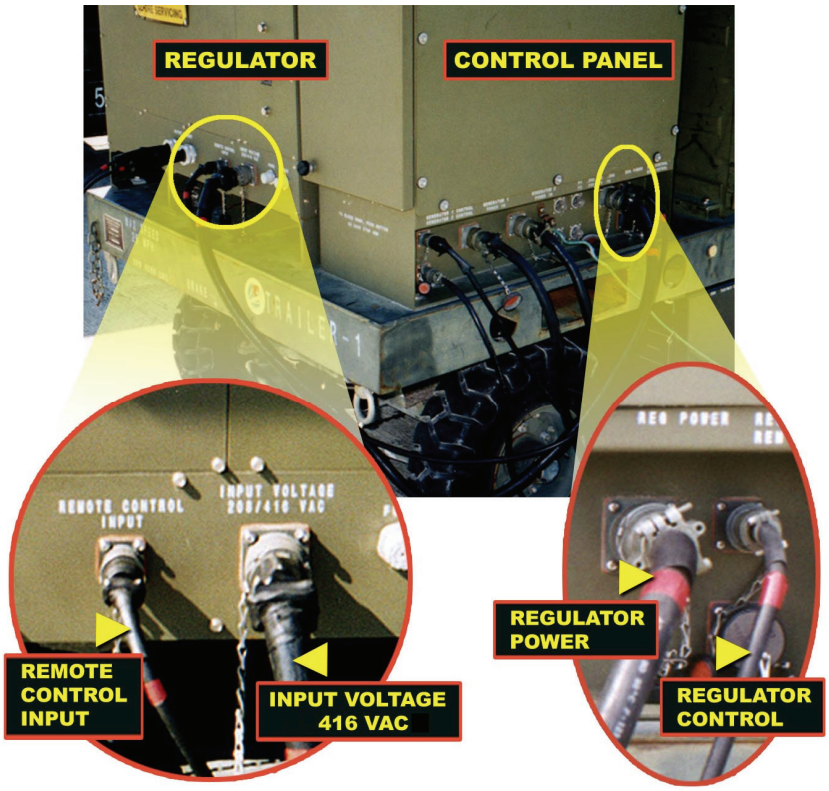


Figure A7.37. Output Current Connectors on Regulator.

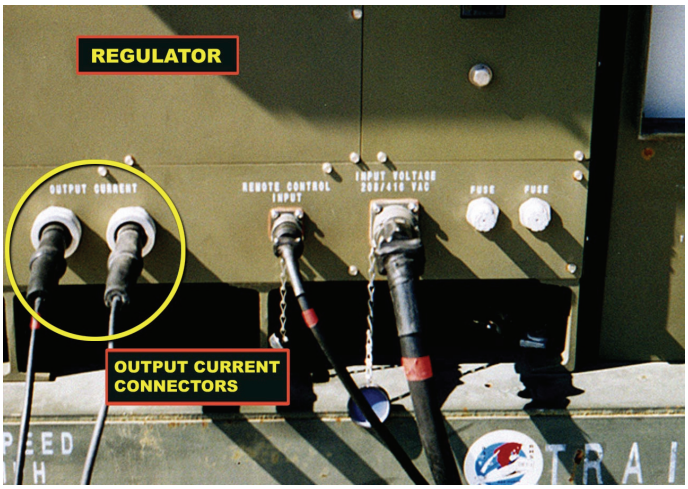


Figure A7.38. P11/J11 Connection on Generator.

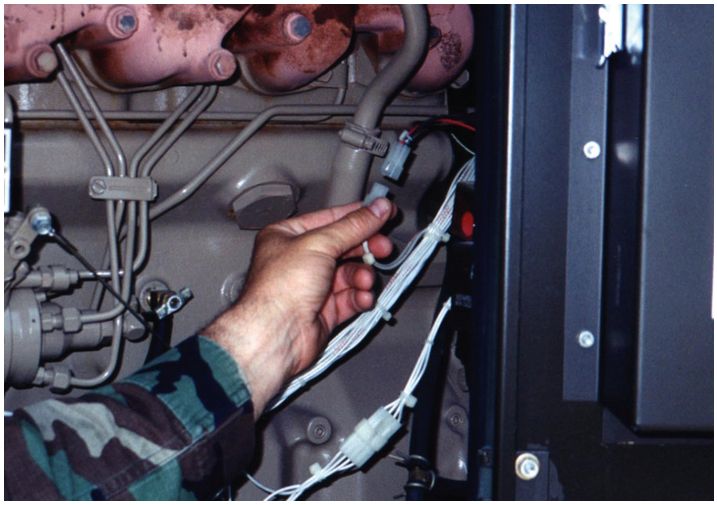


Figure A7.39. Dead Crank Switch.

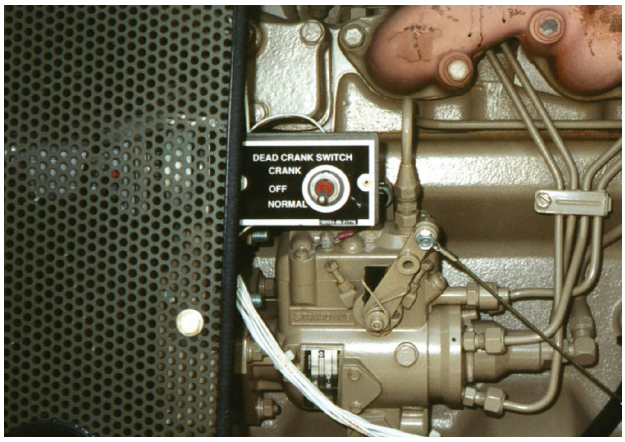
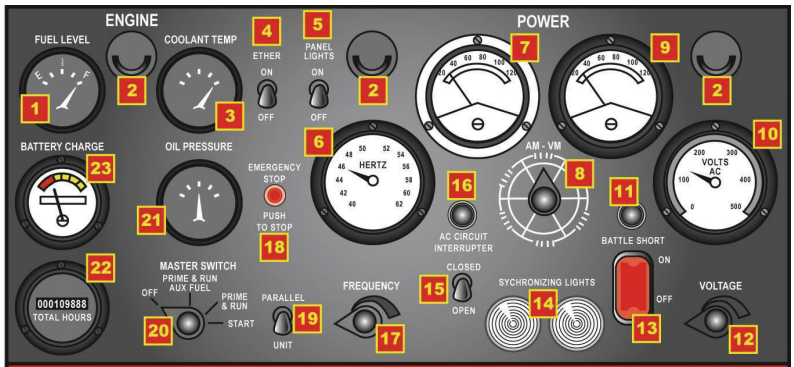


Figure A7.40. Generator Terminal Board #1 (TB1).

Figure A7.41. Generator Control Panel.



	CONTROL OR INDICATOR	FUNCTION
1	FUEL LEVEL indicator	Indicates fuel level.
2	Panel Lights	Illuminates control panel.
3	COOLANT TEMP indicator	Indicates engine coolant temperature.
4	ETHER switch	Activates or deactivates cold starting aid system.
5	PANEL LIGHTS switch	Activates or deactivates panel lights.
6	FREQUENCY meter (HERTZ)	Indicates generator set output frequency.
7	Ammeter (PERCENT RATED CURRENT)	Indicates generator set load current as a percent of rated current.
8	AM-VM transfer switch	Allows selection of current and voltage readings between output load terminals.
9	Kilowattmeter (PERCENT POWER)	Indicates generator set output power as a percent of rated power.
10	AC Voltmeter (VOLTS AC)	Indicates output voltage of generator set.
11	BATTLE SHORT switch	Amber light indicates switch on.
12	VOLTAGE adjust potentiometer	Adjusts generator set voltage.
13	BATTLE SHORT switch	Bypasses protective devices.
14	SYNCHRONIZING LIGHTS	Indicates synchronization of units to be paralleled.
15	AC CIRCUIT INTERRUPTER switch	Opens or closes AC circuit interrupter relay.
16	AC CIRCUIT INTERRUPTER light	Green light indicates AC circuit interrupter is closed.
17	FREQUENCY adjust potentiometer	Adjusts frequency of generator set.
18	EMERGENCY STOP push button	Shuts down generator set.
19	PARALLEL UNIT switch	Energizes or deenergizes paralleling circuits.
20	MASTER SWITCH	OFF - Deengergizes all circuits, except panel lights PRIME & RUN AUX FUEL - Energizes run circuits w/auxiliary fuel pump operating. PRIME & RUN - Energizes run circuits with auxiliary fuel system deengergized. START - Energizes starter.
21	OIL PRESSURE indicator	Indicates oil pressure.
22	Time meter (TOTAL HOURS)	Indicates total engine operating hours.
23	BATTERY CHARGE ammeter	Indicates charge/discharge rate of batteries.

Figure A7.42. Control Bracket behind Generator Control Panel.

Figure A7.43. Regulator Control Panel.

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